1958, No. 2 June 18

Copeia

ESTABLISHED IN 1913

PUBLISHED BY

THE AMERICAN SOCIETY OF

ICHTHYOLOGISTS AND HERPETOLOGISTS

CONTENTS

ICHTHYOLOGICAL NOTES

HERPETOLOGICAL NOTES

NEXT MEETING: The American Society of Ichthyologists and Herpetologists will meet on the campus of Indiana University, Bloomington, Indiana, from Aug. 24 to Aug. 28, 1958, inclusive. The sessions will be held in conjunction with the meetings of the American Institute of Biological Sciences.

Published quarterly by the American Society of Ichthyologists and Herpetologists, 34th St. and Girard Ave., Philadelphia 4, Pa. Second class mail privileges authorized at Philadelphia, Pa. Additional entry at the post office at Baltimore, Maryland.

1958 No. 2 COPEIA June 18

Caecilians of the Seychelles Islands with Description of a New Subspecies

H. W. PARKER

THE STATUS OF *Dermophis larvatus* AHL

In a taxonomic review of the caecilians of the Seychelles archipelago the author (Parker, 1941) perforce left uncertain the status of the name *Dermophis larvatus* Ahl, proposed in 1934 for a larval specimen 58 mm. long in the Berlin Museum. Since no larvae of any of the known species of Seychelles caecilians had ever been described, it seemed possible, or even probable, that the name *larvatus* might either be redundant or have priority for a species known in the adult stage by some other name. So, when the type specimen recently came into the hands of Dr. Ernest Williams of the Museum of Comparative Zoology, he suggested that it should be compared with the relatively extensive caecilian collections in the British Museum. Dr. Heinz Wermuth of the Berlin Museum readily agreed to the suggestion and I am grateful to him not only for the opportunity of seeing the specimen but for his courtesy and patience in answering questions about its history and about other material in his charge.

The specimen is misshapen through excessive dehydration, which accounts for a marked dorso-ventral flattening over most of the body and also, perhaps, for the side-to-side compression of the caudal region, which suggested to the original describer a fin-fold. As already recorded there are 85 body annuli that seem to be mostly, if not all, primaries. There are, however, undoubtedly some secondaries, too, but they are so indefinite, through immaturity and poor preservation, as to be uncountable. Other characters used in the definition and recognition of species in the adult phase are: premaxillary teeth 6; maxillaries 6 on one side and 5 on the other; vomero-palatines 13; outer mandibulars 11; inner mandibulars 4. The tentacle is not fully developed but a depression marks its site; this is much nearer the eye than the nostril, the ratio of its distance from the centre of the former to its distance from the nostril being 0.38. The ratio of the total length to the maximum head width is 33. Of these characters, the numbers of teeth, except on the premaxillary, increase with size; the tentacular opening migrates forwards from the eye during ontogeny and the ratio of length to diameter may also be reasonably expected to undergo changes during development. Consequently these three characters are useful only in comparing specimens at the same stage of development; for comparing adults with larvae the only reliable characters appear to be the number of primary annuli and the number of premaxillary teeth. There are, however, some other immature specimens available for comparison and it is important to note that, contrary to what has previously been reported, the type has a circular gill cleft on each side; in addition, and what has not been recorded before, there is a linear series of shallow circular and oval pits on the canthal and loreal regions, similar to those shown in Figure 1, a specimen of the Kirk collection erroneously recorded from Zanzibar. These pits are believed to be lateral line organs; their structure has not been investigated, owing to the lack of suitably fixed material, but their disposition has some similarity with some of these organs figured by the Sarasins (1887, pl. 5) in larvae and late embryos of *Ichthyophis glutinosus*; they correspond with the infraorbital series of Escher (1925).

Reverting to adult characters, if the 85 annuli are all primaries, the type cannot be *Hypogeophis brevis* (67–68), *H. rostratus* (96–104) or *H. angusticeps* (78–82); it could be *Praslinia cooperi* (83–85), *Dermophis Sechellensis* (82–89) or *H. alternans* (83–88). There is, however, a doubt about the matter, and to obtain a more reliable and precisely countable index, recourse was had to x-ray investigation of the number of vertebrae. The type has 87 and the numbers in the available samples of each of the currently recognised six species of Seychelles caecilians are shown in the histogram, Figure 2. It is clear that *D. larvatus* is outside the known range of variation of *H. rostratus* and *H. brevis* and also outside their probable true

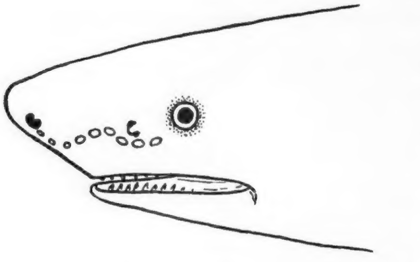

Fig. 1. *Praslinia larvata* (Ahl) Head of 63 mm. larva, showing lateral line organs and tentacular opening.

the latter are shown in Figure 1. The smallest specimen with these larval characters is 47 mm. long and the largest 67 mm. Within these size limits 27 specimens, additional to the type, have been examined and compared. Fifteen of them, ranging from 56 to 62 mm., have neither gill clefts nor lateral line organs. These specimens are almost certainly referable to *H. rostratus,* for their vertebrae range from 102 to 106 (mode 104). It is to be noted that Brauer (1897, 1899) records that *H. rostratus* has no free-living stage, (the whole of the embryonic development being passed inside the egg membrane), that the gill cleft does not persist but closes immediately the

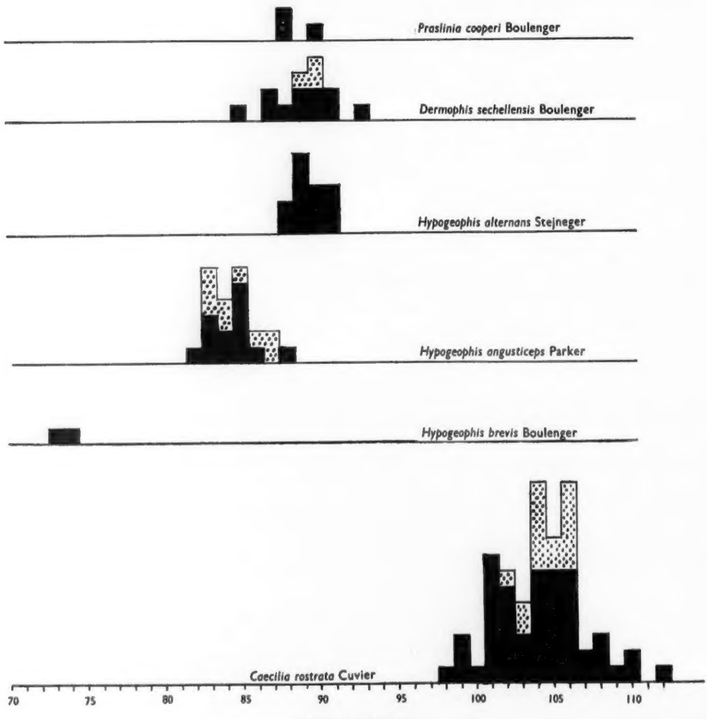

Fig. 2. Seychelles *Caecilians.* Variation in the number of vertebrae in samples of the different species. Larvae or juvenile specimens of less than 67 mm. dotted. (The names are the original combinations).

range of variation. It is, however, within the probable range of variation of the other four species.

In the comparative material there are examples possessing the same two "larval" characters as the type, i.e. gill openings and presumed lateral line organs. The disposition of gills are resorbed and, that lateral line organs, (well developed in *Ichthyophis,* which has a free larval life) do not appear until relatively late in development and disappear a long time before the egg hatches (cf. also Escher, 1925).

The remaining immature specimens, which

have gill clefts and lateral line organs, have from 82 to 90 vertebrae, and so are completely outside the range of *H. rostratus,* and of *H. brevis,* too. They fall into two groups morphologically. Three of them have 89 or 90 vertebrae and seven premaxillary teeth, a combination of characters fitting *D. sechellensis* and nothing else. Confirmation of this determination is also forthcoming from the tentacular position despite the known ontogenetic movement of this organ. In the three larvae the opening is further from the eye than in *P. cooperi,* but nearer to it than in adults of *D. sechellensis*; the ration is 0.15 to 0.20.

The other larvae and the type of *D. larvatus* differ from the three larval *D. sechellensis* in having fewer vertebrae (82–87, mode 84, S. D. = 1.77, n = 10), six premaxillary teeth and, despite the fact that they are on the average smaller (47–64 mm.), a tentacular opening further from the eye; the ratio is 0.38, comparable with that of an adult *sechellensis,* but greater than in larval specimens of that species. These characters are all comparable with what is known of the species currently called *H. angusticeps* Parker. The position is shown, summarised, in Table I, and, if the position is confirmed, the name *larvatus* of 1934 will have to be used in preference to the later (1941) *angusticeps.*

The Generic Status of *Caecilia rostrata* Cuvier

From the histogram, Figure 2, it is evident that an evolutionary series can be traced, from *Praslinia cooperi* through *Dermophis sechellensis, Hypogeophis alternans,* and *Hypogeophis larvatus* (*angusticeps*) to *H. brevis.* In this series there is reduction in the number of vertebrae and an increase in the distance of the tentacle from the eye. *Caecilia rostrata* is off the line of sequence, having many more vertebrae than any of the others, but a tentacle almost as close to the nostril as in *H. brevis,* the species with fewest vertebrae.

C. rostrata differs from the other five species in some other respects, too. In the latest revision of the series Parker (1941) showed that the secondary folds never numbered more than one-third of the primaries in *rostrata,* whereas they numbered two-thirds or more in the other five. The x-ray photographs taken in connection with the current investigations have emphasized this difference. As has long been known, secondary folds are usually associated with double rings of scales in the primary annuli. In the photographs it is clear that in all species ex-

Table I

Species	Ratio $\frac{\text{Tent. Eye}}{\text{Tent. Nostril}}$	P. Max Teeth	Vertebrae			
			Range	Mode	S.D.	No.
Praslinia cooperi Ad.	0.07–0.08	16–18	88–90	89	?	3
Larv.	—	—	—	—	—	0
Dermophis sechellensis Ad.	0.3–0.8	7	85–93	89	2.0	11
Larv.	0.15–0.2	7	89–90			3
Hypogeophis alternans Ad.	1.0–1.3	8–9 (11)	89–91	90	1.07	13
Larv.	—	—	—	—	—	0
Hypogeophis angusticeps Ad.	1.1–1.5	6 (5)	82–88	85	1.59	13
Larv.	0.33–0.38	6	82–87	84	1.53	9
Dermophis larvatus Type	0.38	6	87			1
Hypogeophis brevis Ad.	4.3–5.0	6	67–68			2
Larv.	—	—	—			0
Coecilia rostrata Ad.	1.6–2.3	6 (5)	97–112	103	2.94	53
Imm.	±2.0	6 (5)	102–106	104	1.37	15

cept *rostratus*, when fully adult specimens are considered, there is a double ring of scales in each primary annulus, except perhaps the first five or six; in *rostratus*, on the other hand, double rings of scales occur only in the primary annuli of the posterior third of the body.

A further possible difference between *C. rostrata* and the other species has already been mentioned. It has no free-living larval stage, whereas two of the others, at least, have "larvae" with characters usually associated with aquatic life, and may, therefore, have such a stage. It may be, too, that the differences noted by Brauer (1897) between the ecological preferences of "*H. rostratus*" on Mahé and Silhouette are due to failure to distinguish species. On Mahé it was observed that the animals were strictly terrestrial; the species concerned would almost certainly have been true *rostratus*, the commonest one on the island. But on Silhouette the caecilians were found in the water of streams, and their aquatic habits were well known to the natives. Brauer believed the material he brought back from the Seychelles to be of two species, *H. rostratus* and *H. alternans*; both occur on Silhouette.

In summary, *Caecilia rostrata* Cuvier differs from all the other Seychelles caecilians in its higher number of vertebrae and the reduced number of annuli with double rings of scales; it differs from some if not all of the other species in lacking any free-living stage with spiracula and lateral line organs. As already remarked, the other species form a linear series, but *C. rostrata* does not fit into the sequence. It seems reasonable, therefore, to express these facts by treating it as generically distinct. It is the type species of the genus *Hypogeophis* Peters and its correct name is, therefore, *Hypogeophis rostratus* (Cuvier). So far as the remaining species are concerned, it is uncertain whether they should all be retained in a single genus, for the much greater number of teeth of *cooperi* marks that species off from the rest. For the time being, however, they can be left together until more has been found out about them. There is a generic name available for them, *Praslinia* Boulenger, with *P. cooperi* as its type species.

The Insular Variation of *Hypogeophis rostratus* (Cuvier)

It will be observed from Table I above that the coefficient of variability of the number of vertebrae of *rostratus* is high and markedly higher (2.85) than that of any of the other species. A geographical analysis of the sample indicates that this is due to the fact that the series is trimodal. There are three groups of insular populations that differ from one another to an extent that is statistically significant and the coefficient of variability of each is low and comparable with that of *alternans* (1.2), *angusticeps* (*larvatus*) (1.9) and *sechellensis* (2.2). The actual numerical values are:

Population	Range	Mean	S.D.	No.	C.V.
Frigate Isld	97–102	100.2	1.7	15	1.7
Mahé and Silhouette	100–107	104.9	1.6	36	1.5
Praslin and Curieuse	108–112	109.3	1.4	7	1.3

It seems likely that these geographical differences are genetic and not, as so often in cold-blooded vertebrates, caused by environmental temperature differences during development. This statement is made, despite the absence of the pertinent meteorological information for the different islands, because the Mahé sample includes specimens from various altitudes between sea level and 1200 ft. Such an altitudinal range would involve an orographical temperature difference of about 4.25°F., a difference greater than is to be expected between comparable places on islands within 40 miles of one another, and in the same water-mass. Since no differences have been detected within the Mahé sample that can be correlated with altitude and temperature, it is legitimate to conclude that the insular differences are unconnected with this factor, but are genetic.

That being so, the question of their status arises. Applying the coefficient of difference test (Mayr, Linsley & Ulsinger, p. 146) the coefficients of difference between the Mahé/Silhouette population and those of Frigate Island and Praslin/Curieuse are 1.42 and 1.47, respectively. Thus they amply fulfill the requirement for subspecific recognition (>1.28) in terms of the 97%–75% difference convention. This is, perhaps, more easily appreciated from the accompanying Figure 3. This shows the statistically probable composition of each population, calculated (by the use of "Arithmetical Probability Paper")[1] from the means and standard deviations of the samples; it assumes that the characteristics of these samples are approximately true for the populations as a whole and that the variation of the population is normal and

[1] Some other uses of this special logarithmic paper have been described by Harding, 1949.

symmetrical about the mean. The latter assumption, at least, is justifiable and the former has to be accepted until bigger and better samples are available. From the figure it is clear that, whereas 97% of the Mahé/Silhouette population will have more than 102 or less than 108 vertebrae, 85% of the Frigate population have less than 102, and 83% of the Praslin/Curieuse population more than 108.

There are two names, only, available for consideration in connexion with these three races. First, there is *Caecilia rostrata* Cuvier. The original description makes no mention of any locality, nor does it give any information about the specimen(s) on which it was based. Dumeril & Bibron (1841: 279), however, record that there were two specimens in the Paris Museum either or both of which might have been available to Cuvier. The one (now No. 4270) had been obtained by Dussumier in the Seychelles, and the other (558) was recorded as having been procured by d'Orbigny in South America; the improbability of such a distribution being a natural one was pointed out. Thanks to the courtesy of M. Jean Guibé, both specimens have been examined, and there can be little doubt that both originated in the Seychelles, No. 4270 almost certainly from Mahé and the other possibly from the same island. The former has 105 vertebrae, approximating to the mean value of the Mahé/Silhouette subspecies and outside the range of either of the others; this specimen is hereby designated the lectotype of *Caecilia rostrata* Cuvier. The other specimen has 103 vertebrae, a condition occurring twice as frequently in the Mahé/Silhouette race as in the subspecies from Frigate. The appropriate name

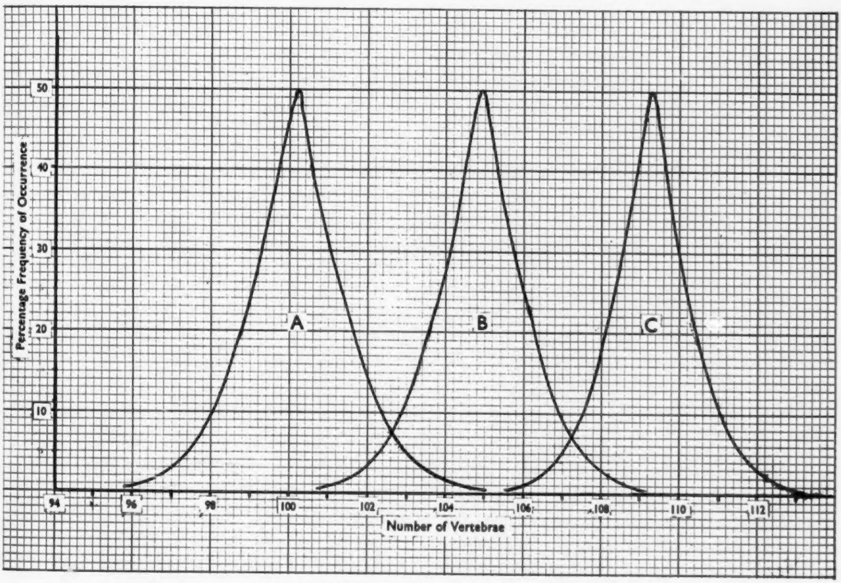

Fig. 3. *Hypogeophis rostratus* Cuvier. Variation in vertebral numbers of different populations; statistically probable percentage frequency of occurrence on Frigate Island, A; Mahé and Silhouette Islands, B; and Praslin and Curieuse Islands, C.

for the *Mahé/Silhouette* subspecies is, therefore, considered to be *Hypogeophis rostratus rostratus* (Cuvier).

The unique holotype of *Hypogeophis guentheri* was originally said to have come from Zanzibar. Reasons for doubting this have already been advanced (Parker, 1941: 7) and the Seychelles suggested as likely. More recently a letter has been found, dated September 25, 1876, which says that the writer is sending to the British Museum a collection of reptiles made by his brother Commodore Parish, R.N. "at Seychelles, Zanzibar and Mauritius"; the whole collection was uncritically registered as from Zanzibar. The specimen has 102 vertebrae, a condition to

be expected in about 15 per cent of the specimens from Frigate, but in only 3 per cent of those from Mahé. Therefore, it is proposed to use the name *guentheri* subspecifically for the insular population of Frigate Island, unless or until it can be shown that the holotype of the name belonged to a different population. In addition to this specimen (B.M.76.10.10.6), sixteen others of *Hypogeophis rostratus guentheri* Boulenger have been seen. They range in size from 175 to 270 mm., and are all definitely known to have originated on Frigate Island and are all in the British Museum.

No name is available for the Praslin/Curieuse race so ***Hypogeophis rostratus* praslini** *subsp.* now is proposed. The holotype is B.M.1907.10.15.135, a female 295 mm. long collected on Praslin by the Percy Sladen Trust Expedition to the Indian Ocean in November 1905. Some characters of this specimen are given by Parker (1941: 7, last specimen listed); additionally, it has 108 vertebrae, and the first double scale ring at the 87th. There are four paratypes from Praslin and two from Curieuse, all in the British Museum. Some of the external features of four of these have been given by Parker (1941: 6–7); there are 108 vertebrae in two, 109 in one, 110 in two, and 112 in one. The race is distinguished above.

Regarding the origin and interrelationships of the three subspecies, little can be said. They are almost equidistant one from the other both morphologically and geographically. It can only be assumed that they are the remains of a single species that formerly occupied a larger land mass now fragmented.

Summary

1. The holotype of *Dermophis larvatus* Ahl 1934 is probably a larva of the species described by Parker in 1941 as *Hypogeophis angusticeps*.

2. The species originally described by Cuvier as *Caecilia rostrata* differs from the other Seychelles caecilians in some morphological features, notably a reduction in the number of annuli bearing double rings of scales, and probably in the complete suppression of a free aquatic larval stage. These differences may warrant its separation from the remaining species of the archipelago as a monotypic genus, *Hypogeophis*.

3. The species *Hypogeophis rostratus* has three recognizable insular races characterized by different numbers of vertebrae. These differences, not a temperature effect, are probably genetic, and warrant the recongition of three subspecies. Names are available for two of these and a new name is proposed for the third.

Acknowledgments

The author wishes to acknowledge his gratitude not only to those persons already mentioned, but also to Mr. P. E. Purves of the Zoological Department of the British Museum (Natural History) for the numerous excellent radiographs, which have been an essential ingredient of the investigation, and to Lord Richard Percy and the Honourable Matthew Ridley, who obtained valuable new material for the work during their recent investigation into the results of the commercial exploitation of the Sooty Tern in the Seychelles Archipelago.

Literature Cited

AHL, E. 1934. Ein neuer Schleichenlurch der Gattung Dermophis von den Seychellen. *Zool. Anz., 106; 11: 284.*

BRAUER, A. 1897. Beiträge zur Kenntniss der Entwicklung geschichte und der Anatomie der Gymnophionen. *Zool. Jahrb., Anat., 10: 389–472, Pls. 34–37.*

———. 1899. Beiträge zur Kenntniss der Entwicklung und Anatomie der Gymnophionen. II. Die Entwicklung der äussern Form. *Zool. Jahrb., Anat., 12: 477–508, Pls. 22–25.*

CUVIER, G. 1829. Regne Animal, second ed., *2: 100.*

DUMERIL, A., AND BIBRON, G. 1841. Erpétologie Génerale, *8: 279.*

ESCHER, K. 1925. Die Seitenorgane der Wirbelthiere. *Acta Zool., 6: 307–414.*

HARDING, J. P. 1949. The Use of Probability Paper for the Graphical Analysis of Polymodal Frequency Distributions. *Jour. Marine Biol. Assn., U. K. 28: 141–153.*

MAYR, E., LINSLEY, E. G. & USINGER, R. L. 1953. Methods and Principles of Systematic Zoology. *McGraw-Hill, New York.*

PARKER, H. W. 1941. The Caecilians of the Seychelles. *Ann. Mag. Nat. Hist., 11, 7: 1–17.*

SARASIN, P. AND F. 1887. Ergebnisse naturwiss. Forschungen auf Ceylon. in den Jahren 1884–1886, II. (Wiesbaden)

BRITISH MUSEUM (NATURAL HISTORY), LONDON.

Olfaction in Rattlesnakes

R. B. Cowles and R. L. Phelan

This report comprises the results of preliminary investigations on the ability of rattlesnakes to perceive airborne odors of two types; attractives in the form of food including its various stages of putrefaction, and repellent odors in the form of scents of three animals feared by these reptiles. This research was supported by a research grant from the Richfield Oil Corporation.

The subsidiary objectives of the first phase of these investigations included tests as to the acuity and utility of chemoreception, and degrees of acceptance of putrifying protein as a source of food. Also involved was the possibility that carrion might serve as a carrier for toxins to be employed in control of these reptiles.

Knowledge on the subject of food preferences may prove to be important in a wider sense than merely a means for the destruction of snakes because our larger species of ophidians have been rather generally believed to be important in rodent control, hence if they are found to prefer dead animals as well as the moribund and the weak among their prey animals they will fit rather neatly into the newly recognized but well-known role of the predator scavenger functioning as sanitary agents.

A second objective was the acquisition of information that could be employed in controlling local populations of rattlesnakes by means of repellent substances placed along the boundaries of areas from which their exclusion would be desired. The possibility of discovering effective repellents should be of interest to biologists since the usual methods for snake extermination, traps, fumigation of burrows and dens and the employment of poisons (Stickel 1953) are nonselective and if effective are ipso facto dangerous to other animals as well.

Methods

Four species of rattlesnakes from the southwestern United States were employed. *Crotalus atrox* from the Coachella Valley where it exists in oases-like environments within the extreme desert; *Crotalus scutulatus* of the more moderate deserts in the Mojave area; *Crotalus ruber* of the more mesic chaparral and locally into the edge of the desert; and *Crotalus viridis*, a climatically more plastic species with a wide range in the western United States. Within these species are representatives from markedly different environments that range from subhumid to extremely arid. If data for these animals is consistent in our samples, the results may be applicable to other species throughout the United States.

Response to Food Odors

Semistarved animals that were to serve in these tests were placed in large, brightly lighted glass-and-metal cages covered with heavy opaque wrapping paper and housed in a darkened room. At one end of the cage, holes were drilled through the glass in order to admit air ducts. Substances whose odors were to be tested were placed in aqueous solutions in jars that were fitted with two-hole stoppers. In the tests air under low pressure was passed through the jars with their test contents and the air-flow was regulated by means of tubing clamps.

In the first tests of the apparatus we employed a protein whose odor was completely beyond the experience of any rattlesnake, namely cow's milk either natural or dried. Because no satisfactory responses were evoked by the undecomposed milk (other than a weak and apparently nonsignificant tongue protrusion) the milk was allowed to decompose whereupon the snakes responded in a satisfactory manner. They also responded positively to the odor of putrescine which might be called a totally foreign and purely biochemical odor for a stage in putrefaction. In all subsequent tests puffs of plain air and air passed through water were employed as controls and these were then followed by the odors to be tested.

There can be little doubt as to the validity of the tests and observations. Each test was preceded by a period of observation to determine whether the reptiles were restless and thus might simulate a positive response. After observing that all of the animals were resting and undisturbed the control tests were given and if these resulted in a short period of air sampling followed by a return to passivity the experiment was started. After completing the controls, the odors to be tested were injected in puffs and if one or more snakes could be induced to uncoil and

follow the scent for most of the distance to its source, sometimes as much as six feet, the responses were accepted as being clearly positive. For additional proof that the snakes were indubitably responding to odor, one of them was subjected to puffs of a scent directed to alternate sides of the cage. The snake followed the odor from left to right in a succession of direction changes until it eventually reached the actual source of the odor at the opposite end of the cage.

Throughout experimentation, both in the food tests and fear reactions, temperatures were kept within a range of 26°–28°C., that is, at approximately normal levels.

Results

Neither dried nor fresh milk evoked more than a transitory lingual response. At no time did the snakes move out of their resting positions to explore "upwind" toward the source of the odor. Milk that was allowed to decompose for as much as 2–4 days at 26°C. evoked clear-cut responses by one or more snakes. Although most of the snakes might show increased activity, at no time did all of them respond simultaneously in an identical manner.

After being thoroughly convinced that only the odor of putrifying milk could evoke positive reactions in our snakes, and that the smell of dilute solutions of nicotine sulphate were not repellent to them, a fresh solution of powdered milk was allowed to sour for two days at approximately 26°C. after which the poison was added to make a 5% solution. This mixture was then placed in the cage with several rattlesnakes whereupon a *Crotalus viridis* crawled to the receptacle and investigated this test bait by sampling the air around and over the pan. The tongue was observed as it actually entered the solution at least once and possibly more times, each time resulting in withdrawal of the tongue and departure from the pan. Shortly thereafter the animal experienced a series of convulsions and appeared to be moribund but it had recovered by the following day.

This test was repeated with another snake with the solution increased to 10%. Since no snake approached the pan, the observer left the laboratory for an hour during which time the snake had either consumed or tested the more potent mixture and was already in a convulsed state. This animal became greatly contorted in the manner assumed after poisoning by nicotine or even finely ground tobacco, and was dead a short time later.[1]

Tests for acceptability of dead animals in different stages of putrefaction followed the same pattern as those for milk. White mice and rats were employed and their use was warranted since the snakes had been fed on them for some months prior to the tests. It seemed possible that a change to wild species would have produced no better results.

Prior to the early stages of putrefaction the results with meat were identical to those with milk except that in the latter, up to some undefinable stage of putrefaction, the attraction seemed to be stronger than for the meat. By the fourth day at the temperatures under which the tests were conducted the test meat became putrid and a definite rejection or negative response was evoked when the snakes approached to within two feet of the odor source and they were driven away by a prolonged puff of the odor. The avoidance response was not observed at any stage of decomposition except extreme putrefaction. At this stage the meat was so foul-smelling that the experimenters were driven from the laboratory.

In a graphic test of food preference two large white rats were dismembered and were allowed to ripen for thirty hours at approximately 30°C. and the fragments were then placed in a cage containing fifteen rattlesnakes of the aforementioned species. Forty minutes prior to introducing the putrid meat a freshly killed mouse was dropped in the cage among the snakes. The fresh food was ignored throughout the entire test whereas when the putrid meat was placed in the cage most of the snakes became alert and searched about the cage. Two snakes found easily consumable fragments and promptly swallowed them but the larger, irregularly shaped chunks appeared to be difficult to swallow despite repeated attempts by several snakes. Meanwhile, the freshly killed mouse was completely overlooked.

Field tests of odor perception conducted in the summer of 1955 and again in 1956 were essentially failures. In each case 15 white rats were wrapped in white paper (white was used to enhance visibility and conceal them from buzzards) and were distributed along a dusty ridge top road bordered by extensive chaparral and grasslands. The packages were placed at approximately

[1] I am indebted to an African Zulu for the information on the toxicity of tobacco as snuff and to Mr. Anton Christ and Dr. R. C. Stebbins for passing along that hint that milk might serve as a bait with crude nicotine garden spray at the poison.

equal distances from each other. Throughout the hours when visibility was adequate a close watch was maintained on the baits and at intervals a check for tracks in the dust was conducted without stepping from the automobile. Neither tracks nor observation of the objects provided signs of any activity other than by buzzards. In each test the baits were left overnight and until 10 AM the following day and none was disturbed until buzzards arrived and stripped the papers from the baits.

The absence of interest on the part of other nocturnal and diurnal scavengers, whether ophidian or mammlian, may be explicable by the assumption that none was near enough to pick up the odor of the baits. The buzzards cruised back and forth in the ridge top breeze, detected the odor, overshot the baits on the first upwind return sweep, circled down and then upwind again and landed almost precisely on a bait. I believe that odor was their cue although some ornithologists may prefer to attribute detection of their food to visual cues, in this case, supposedly the movements of sarcophagid insects.

It is probably worth noting that while early decomposition up to an apparently definite but presently undescribable stage is acceptable and from our experiments possibly even attractive, a more advanced stage is repellent. Casual observations indicate that similar discrimination may be exercised by all vertebrate carrion-eaters and that beyond a certain stage (or possibly only through certain stages) of decomposition carcasses are abandoned. It would not be surprising to discover that certain bacterial flora in the succession common to decay produce toxins and that scavengers can detect the condition.

Repellent Odors

Cowles (1938) has described the special defense and fear reactions of two species of rattlesnakes, *Crotalus cerastes,* and *Crotalus viridis* to the airborne odors of both *Lampropeltis getulus,* the common king snake and the spotted skunk, *Spilogale phenax.* Bogert (1941) has confirmed this reaction to the king snake and additionally has pointed out that the odor emanates from the dorsal region of this ophiophagous snake as well as from its ecological counterparts from South America.

On the basis of these observations it was believed that the odor of skunk musk or a more easily obtainable substitute might evoke the fear reaction and thus serve as a practical repellent to rattlesnakes.

In order to test both the mechanism of detection and the induction of fear, it was necessary to find a commercially available substance which closely simulated the odor of skunk musk. Thio-alcohol n-butyl mercaptan was chosen for the tests. This chemical has been used by L. A. Ford and associates (1938) as a rodent repellent and it was found to be very satisfactory for the purpose. These authors report that this mercaptan is "the active component of the odor of skunk" and that no grain which had been treated with this material was molested by rodents throughout a period of four months subsequent to application. The odor of the mercaptan and that of the skunk musk are not greatly dissimilar when judged by olfactory responses of human beings.

Preliminary experiments with these substances and observations of the gross reactions of the rattlesnakes failed to demonstrate clear evidence of fear unless they were touched or detected movement. Failure was due to the fact that without the addition of visual or tactile stimuli the rattlesnakes remain quiescent in tonic immobility or similar reaction. Because of the consistency of this response it became necessary to discover some other technique for determining the animal's reaction to fear-inducing odors.

On several occasions, the sides of rattlesnakes were observed to "flutter" when they were closely approached by a king snake, and James Warren reported (verbal communication) a change in heart rates in snakes when they were disturbed. Although no external reaction was seen to take place during mercaptan tests it was believed that a change in heart rate might serve to detect a concealed fear reaction, and that this might be recorded by employing an office type electrocardiograph, using electrodes implanted under the skin. It was found that very satisfactory electrocardiograms could be obtained and that heart rates could be recorded continuously during the course of odor stimulation.

The control substances employed in this experiment were "neutral" odors such as water, plain air, or food followed by the odor to be tested. The preliminary control substances induced virtually no detectable change in the heart rate. This may result from the relative insensitivity of our instrument.

Procedure

The experimental animals were enclosed in the vision-proof cage described previously, and when they appeared to be at rest and not alarmed by any external stimuli including vibrations caused by the investigator, the electrocardiograph was turned on and the "resting" rate was recorded. Without interrupting the record, puffs of the "nonfear" substance were admitted to the cage, the record being marked to indicate the exact time when this was commenced. After several seconds had elapsed to insure that the snake had detected the odor (this interval having been determined beforehand in previous experiments) the "fear" stimulus was blown into the cage, the continuously running record again being marked to indicate the time of stimulation. Rates and percentage differences were then calculated from the calibrated record.

Results of Typical Repellent Experiments

A significant increase in rate was never detectable in response to neutral stimulae but there were changes when the animal was inadvertently disturbed by actions of the investigator. These alterations in rate were irregular and obviously resulted from factors unrelated to the experimental stimuli under test. The fear stimuli were always preceded by the control stimulus and the method of appliciation was identical for both. In the absence of perturbations mentioned above, repeat runs were always consistent with any given individual except that percentage increases in rate for all stimuli decreased with time and repetition of the experiment, presumably this result being due either to more or less permanent suffusion of odor in the cage or to deconditioning.

Thus it is seen that known fear-evoking stimuli such as the odor of king snake, sight of human beings (by either visual or infrared perception) and vibrations of various kinds will cause a sharp rise in the heart rate while other stimuli do not. Normal butyl mercaptan, which simulates the odor of, and exists in, skunk musk, causes a rise in heart rate similar to that caused by king snake odor, which is seemingly not perceptible to at least the average human being's olfactory senses. Furthermore one specimen, a *Crotalus ruber*, was observed to exhibit typical king snake defense reactions as reported by Cowles, *ibid.*, and Bogert, *ibid.*, when touched with a stick immediately after a mercaptan run. This snake did not react similarly to the same handling prior to the test.

For those who may wish to repeat this easily conducted experiment or who might wish to demonstrate it in a laboratory, a word of caution should be inserted.

A wholly incidental by-product of the procedures described was the repeated observation that rattlesnakes appear to possess some extremely acute mechanism for the reception of mechanical vibrations. This sensitivity far surpassed anything which the present authors expected from many years of casual observations. Vibrations set up by the clicking of apparatus, footsteps on a massive basement concrete floor, or even in some cases a cough of moderate intensity were sufficient to startle all but the most phlegmatic of the exprimental animals and thus alter the data. The methods of transmittal and reception have not been studied. Loreal pit stimulation

Table I

Fear Reaction Based on Changed Heart Rate

Species	"Resting" Rate	Non-Fear Rate Milk Odor	Fear Rate	Percent Increase of Heart Rate
C. viridis	46/min	46/min (sour milk)	54/min (mercaptan)	15
C. viridis	44.6/min	45/min (sour milk)	51.9/min (king snake odor)	16
C. atrox	34.7/min	34/min (water)	50/min (king snake)	45
C. atrox	33.3/min	33.5/min (water)	46.7/min (mercaptan)	40
C. atrox	37.5/min	—	58.9/min (king snake)	57
C. atrox	33.6/min	33.5/min (sour milk)	42.8/min (human perspiration)	27
C. atrox	37.5/min	35.1/min (sour milk)	44.5/min (king snake odor ether extracted on rag)	26
C. ruber	40/min	41/min (water)	60/min (king snake ether extracted odor)	42
C. ruber	39/min	40.5/min (water)	55.5/min (mercaptan)	37
C. ruber	35/min	38/min (water)	55.5/min (mercaptan)	32
C. ruber	39/min	40/min (air)	55.5/min (mercaptan)	38
C. scutulatus	34/min	32.3/min (air)	41/min (mercaptan)	27

should also be avoided. It should be emphasized that accurate and consistent results can be obtained only when the experimental animal is completely at rest and unaware of the presence of an investigator. This sensitivity to sound was so acute that it was frequently necessary to extend the periods of preliminary waiting while in position with all paraphernalia at hand, until a flawless run could be obtained.

One of the most interesting observations based on these heart rate counts was that in highly responsive individuals the greatest observed percentage increase in heart rates resulted from the sight of humans, while a definite and consistent increase resulted from stimulation with human odor by passing air through an undershirt (relatively clean).

Odor Detection

Observations of rattlesnake behavior under the aforementioned experiments suggested that under some conditions these animals might utilize their capacity for olfaction to a greater degree than is ordinarily suspected, and since there is relatively little information on the respective roles of types of chemoreception (normal olfaction vs. Jacobson's organ) in the biology of reptiles, the results of this observation may be of interest. Two simple experiments were employed.

In the first experiment the snakes were left undisturbed in a special cage until all were at rest. After a period of observation to insure that no snake in the cage was alert and during which time there was no movement or evidence of tongue-sampling, puffs of air were admitted to the cage. This was followed after a pause by puffs of odor-bearing air. Faint odors such as water, fresh meat, fresh and slightly spoiled milk, etc., as well as strong odors (highly putrefied meat, milk, acetic acid and others were used). The odor bearing substance was administered in the same manner and duration as the controls.

In some 25 repetitions no response to any of the control substances was observed whereas with the odor-bearing material, except in one instance, reactions were clearly discernible. If the snakes had reacted to tactile stimuli from puffs of air or vibrations set up by the gentle hissing noise of air passing through the tubes, they would be expected to respond uniformly. This was not the case. Furthermore in this as well as in previous experiments there was a definite correlation between the intensity (to the investigator) of the odor and the number of snakes responding and the delay between stimulation and response.

The sole instance of air sampling evoked by plain dry air might be explained on the basis of this air having a detectable odor imparted to it by the rubber and plastic involved in the air and tube system.

In a second test, the mouth of a *Crotalus atrox* was securely taped in such manner that protrusion of the tongue to even the smallest degree was impossible. The snake was then exposed to various odors by the methods already described. Changes in heart rate, as recorded by electrocardiograph were used in determining the response to odor. Controls were used in the manner similar to the foregoing in order to eliminate the possibility that any elicited response was due to a stimulus other than olfactory.

In the first tests, with taped mouth, the reptile was exposed in sequence to the odors of sour milk, putrescine, and king snake. The first substance resulted in no change, or very slight almost imperceptible alteration in rate; the second caused a transient increase in heart rate after a short delay. The fear stimulus caused a persistent increase after long delay. This test was repeated using n-butyl mercaptan as a fear-inducing stimulus with similar results except that the delay after the fear stimulus was shorter. When other controls were used it was found that any substances having a strong odor resulted in a transient increase in rate after a short delay. An experiment in which plain water was used as a control followed by the mercaptan fear-stimulus resulted in a 28.8 per cent increase over previous heart rates.

Discussion

These results are interpreted to mean that rattlesnakes possess an olfactory chemoreceptive alerting mechanism, possibly of low discrimination but high sensitivity, which operates independently of the tongue and Jacobson's organ and probably serves as a trigger mechanism for the lingual air sampling responses. This implies that alerting may be initiated from a resting nonalert condition by the arrival of vagrant airborne odors such as that of putrefying protein or the presence of a dangerous predator, and that following such general stimulation a more explicit analysis by the use of the tongue and Jacobson's organ may follow.

On testing a possible predilection of some

western species of rattlesnakes for slightly decomposed food it was demonstrated that from a mixed batch of freshly killed and slightly decomposed, hence more odorous, animals, those that had just been killed were not consumed. Additionally, on testing the airborne odors of putrefying proteins, such as milk, mouse flesh and putrescine, positive responses were evoked only by the odors that to human olfaction were both disagreeable and stronger. These responses may be explained by the supposition that in the absence of a visual stimulus produced by attention-getting movements of prey, the snakes were forced to rely on a less effective sense-receptor than eyesight and hence could perceive only conspicuous odors.

Irrespective of which senses may determine the feeding reaction of these snakes the fact remains that in the absence of available living prey hungry rattlesnakes would detect and readily consume dead food, notably the decomposing bodies of small animals. To this degree these rattlesnakes qualify at least secondarily as scavengers.

As yet, there has been no experimentation to determine whether these snakes react more compulsively to suitable olfactory than to visual stimulae in selecting their food. Valid experiments would have to be conducted on unconfined and unrestrained snakes in the field. There is, however, some support for the possibility that even rattlesnakes, despite their lethal armament, may fear their living prey. Most snakes display obvious signs of nervousness, sometimes almost amounting to panic, when small but active rodents are in the cage with them. This is usually ascribed to the unnatural conditions of confinement but it is noteworthy that under these conditions when a strike is finally ventured it is most apt to be administered as the victim is passing across the field of danger or away from it rather than when it makes a direct frontal approach toward the snake. This fear reaction is so compelling that even excitable rattlesnakes can be picked up by pushing a hand directly at them (when they will usually flatten their coil) then pinning their head to the ground. This is not a recommended procedure, however. These evidences of fear in conjunction with the known inclination of all organisms to expend only a minimum amount of effort while procuring their food certainly suggests the possibility that in the normal course of events rattlesnakes may be far more accustomed to feeding on carrion than we have believed. However, if it is to be assumed that carrion may make up a considerable part of their food, the abundance and accessibility of dead versus living prey should be established. As to the availability of dead animals in the wild, no information apparently is available, but it is a well-known fact that the reproductive rate of their prey may amount to as much as several hundred per cent per year and that under normal conditions no increase in the total population results from this great reproductive capacity.

Such a high reproductive rate as that of rodents demands an equally high mortality rate and this mortality is not inflicted solely by vertebrate predators but includes death by lack of shelter from the elements, lack of food, parasitic diseases of bacterial and helminth origin and probably genetic disabilities as well. Spring, summer, and early fall are the feeding times for snakes and these are also the periods for both reproduction and the most extensive thinning of the callow young that comprise most of the potential surpluses. Late fall, winter and early spring continue this pruning of the population but presumably the snakes would be in hibernation, hence unaffected by food supplies.

There seem to be no genuine data on the relative effectiveness of population-cropping by predators versus disease but the variety and ubiquity of death from other causes than predation must be very high, sufficiently high to supply abundant food in the secretive kinds of places that snakes should be most capable of investigating and which are inaccessible to avian and large mammalian scavenging competitors.

From available evidence it seems to this writer that until additional knowledge from field studies is at hand we cannot assume, as is presently the case, that rattlesnakes are unqualifiedly valuable as rodent controls.

In studies of the effects of fear-inducing odors on rattlesnakes it was found by the use of an electrocardiograph the physiological changes induced by fear could be detected and recorded. Odor from the dorsal region of the common king snake, n-butyl mercaptan which simulates skunk musk and the body odor of a human being elicited a marked fear reaction as revealed by changes in heart rate.

It is expected that field tests of this particular mercaptan, possibly adsorbed to charcoal, may provide an effective and inexpensive repellent for use around areas where rattlesnakes are not wanted. Its several month's success as a rodent repellent (Ford

1941) would contribute to its total effectiveness and suggests prolonged utility against the snakes themselves as well as their food. Most amusing was the observation that of the three odors tested, that of the human being produced a high increase in heart rate.

Of greater value than snake control is the demonstration that by employing a more sensitive electrocardiograph as a form of lie detector it should not only be possible to discover numerous repellent or fear-inducing substances and animals, but also it might be employed to discover the degree to which various intensities and wave lengths of sound can be detected and the method of their perception. It should be of value in measuring the temperature reactions of reptiles and their abilities to adapt to temperature changes and many other features of ophidian physiology-ecology.

Control of Dangerous Snakes

It is probable that many years of extremely difficult and painstaking field observations will be required to settle the issue as to the precise role of rodent-eating snakes in the complicated question of their total effect on man's economy. I believe it probable that they like all predators capture the easiest victims first, those marked out by weakness, nonalertness or other abnormalities or behavior and in this manner contribute to maintenance of rodent community health by eliminating contagion carriers that would otherwise serve to disseminate diseases or even cause epizootics. Carrion eating would also serve as a hygienic factor. In this sense reptiles might serve to suppress outbreaks of such diseases as sylvatic-bubonic plague or tularemia and hence they might be considered temporarily beneficial, whereas, if by this means they also contribute to rodent welfare as a whole, they might be considered inimical to man's welfare. It is entirely probable that when the final answers are available rattlesnakes will be found to have conflicting effects on populations of rodents.

Having mentioned what appears to be a simple and effective means for poisoning rattlesnakes I feel impelled to restate the views of all herpetologists, namely that except in clearly demonstrable instances where their local destruction might save human life, rattlesnakes should be preserved if for no other reason than that they are members of our vetebrate fauna. Preferably only some repellent devices should be used, including the elimination of their rodent (and lagomorph) food supplies. Field tests may demonstrate a double value in n-butyl mercaptan as simultaneously repellent to both snakes and mice.

Although the writers have no desire to increase the commercial value of horse hair ropes it may be appropriate to re-emphasize the fact that snakes that were tested reacted strongly to human odor, hence any odor-absorbing rope, horse hair or not, even personal clothing, should serve as a barrier to prowling snakes in search of a warmed sleeping bag.

Literature Cited

Bogert, C. M. 1941. Sensory Cues Used by Rattlesnakes in Their Recognition of Ophidian Enemies. *Ann. N. Y. Acad. Sci., 41, (5): 329–43.*

Cowles, R. B. 1938. Unusual Defense Postures Assumed by Rattlesnakes. Copeia, (1): 13–16.

Ford, L. A. (and associates). 1941. Rodent Repellent Tests. Chemical and Engineering News. 19(14): 783.

Klauber, L. M. 1956. Rattlesnakes, Their Habits, Life Histories and Influence on Mankind. 2 vol. *Univ. Cal. Press, pp. 1–1476.*

Stickel, W. H. 1953. Wildlife Leaflet No. 345. *U. S. Fish and Wildlife Service.*

Department of Zoology, University of California at Los Angeles, Los Angeles, California.

Human Envenomation from Bites of Recently Milked Rattlesnakes: A Report of Three Cases

Henry M. Parrish and Robert E. Thompson

Venomous snakebites may be considered an occupational disease among herpetologists, professional snake handlers, and amateur snake collectors. In a recent study one of us (H.M.P.) interviewed 41 persons who handle snakes routinely, and dis-

covered that 32 of these individuals had been bitten one or more times by a venomous snake. Because of conflicting reports in the literature and a sense of false security, many persons do not regard recently milked snakes as potentially dangerous. The purpose of this paper is to report three cases of human envenomation resulting from bites by recently milked snakes. There are few medically documented reports of pit viper envenomation from recently devenomized snakes.

The patients in this study are employees of Ross Allen's Reptile Institute, Silver Springs, Florida. They milk hundreds of pit vipers annually, and give lectures and demonstrations of reptiles to tourists. One of us (R.E.T.) serves as company physician for the Institute, and the other author was asked to see these patients in consultation for treatment. All patients were admitted to the Munroe Memorial Hospital, Ocala, Florida, for observation and treatment. For determining the severity of the snakebites, the clinical classification of pit viper venomation devised by Wood, Hoback, and Green (1955) was used. They classify bites as minimal, moderate, and severe venenation depending on the amount of local swelling, the presence or absence of systemic symptoms, and the clinical course of the patient during the first twelve hours of hospitalization.

Case Reports

Case 1.—(W.H.G.), a 39-year old white male, received his first venomous snakebite from a 4½ ft. canebrake rattlesnake (*Crotalus horridus atricaudatus*) which had been milked 24 hours previously. The victim was struck by one fang at the base of the right index finger while picking up the snake during a lecture. He experienced immediate burning pain, and local swelling developed within a few minutes. A tourniquet was applied around the patient's wrist and he was rushed to the hospital. Thirty minutes after envenomation the swelling had spread to the dorsum of the hand. The patient appeared pale and his skin was cold and clammy. His blood pressure was 100 systolic and 76 diastolic, and he complained of numbness of the face. Treatment consisted of: excision of an area of 1.5 cm. diameter surrounding the bite and including the fang puncture; five incisions on the dorsum of the involved hand; suction; a transfusion of 500 cc. of whole blood; Wyeth's Antivenin (Crotalidae) Polyvalent 10 cc. in the dorsum of the right hand and 10 cc. in the right deltoid muscle; tetanus antitoxin, 1500 units daily for three days; Achromycin, 250 mg. four times a day; and cryotherapy for eight hours after suction was discontinued. The patient's temperature remained normal during his hospitalization, and analyses of his blood and urine remained normal. Twenty-four hours after envenomation the swelling had extended to just below the axilla. The patient was discharged from the hospital four days after admission, and no wound complications developed. This rattlesnake bite was one of moderate venenation.

Case 2.—(C.M.B.), a 25-year old white male, received his first venomous snakebite from a 3 ft. eastern diamondback rattlesnake (*C. adamanteus*) which had been milked 48 hours before. The patient was bitten at the base of the right forefinger with one fang while attempting to milk the snake during a lecture. Pain and swelling developed within a few minutes; however, the patient did not develop any systemic symptoms. A tourniquet and incision with suction over the site of the bite were used immediately. The patient arrived at the hospital 30 minutes later, at which time the swelling had advanced to the wrist. The patient's blood pressure and pulse remained within normal limits. Treatment consisted of the following: excision of a 1.5 cm. area including the site of the bite; seven incisions on the dorsum of the hand; suction; Wyeth's Antivenin (Crotalidae) Polyvalent, 10 cc. in the dorsum of the involved hand and 10 cc. in the right deltoid muscle; tetanus antitoxin, 1500 units daily for three days; Terramycin, 250 mg. four times a day; Demerol, 100 mg. as needed for pain; and a transfusion of 500 cc. of whole blood. The patient's temperature rose to 101°F. on the second hospital day, and he developed a leukocytosis of 23,000 W.B.C.'s. Twenty-four hours after envenomation the swelling extended to just below the axilla; axillary lymphadenopathy was present. The patient was discharged from the hospital four days after the snakebite; however, he developed aseptic necrosis of the bite site which required three weeks for healing. This snakebite was one of moderate venenation.

Case 3.—(C.M.B.), the same patient as in Case Report 2, suffered his second venemous snakebite from a 5½ ft. eastern diamondback rattlesnake (*C. adamanteus*) which pierced the lateral surface of the right leg just below the knee with one fang. This snake had been milked of its venom 24 hours previously. The

patient sensed a burning pain at the site of the bite almost immediately. Five minutes later he experienced numbness and tingling of his tongue, lips, face, and extremities. He felt nauseated, but did not vomit. Immediate first-aid treatment consisted of a tourniquet and incision with suction over the site of the bite. When the patient was examined at the hospital 20 minutes later, the swelling extended for an area of approximately 10 cm. surrounding the fang site. The patient's pulse and blood pressure were within normal limits; his blood pressure was 124 systolic and 84 diastolic. Treatment consisted of: excision of a 3 cm. area including the bite site; 5 superficial incisions in the surrounding edematous tissue; suction; Wyeth's Antivenin (Crotalidae) Polyvalent 10 cc. infiltrated in the bite area and 10 cc. injected into the right buttock; 1500 units of tetanus antitoxin daily for two days; Achromycin, 250 mg. four times a day; and Demerol, 100 mg. as needed for pain. The patient's temperature rose to 100°F. on the second hospital day, and he exhibited a leukocytosis of 12,000 W.B.C.'s. The urine and hemoglobin values remained normal. The swelling eventually extended from six inches above the knee to six inches above the ankle. The patient was discharged from the hospital four days after his snakebite. No wound complications developed. This pit-viper bite may be classified as one of moderate venenation.

Discussion

These three case histories of patients who suffered moderate venenation from recently devenomized rattlesnakes suggest that either all of the venom was not extracted at the time of milking, or a fresh supply of venom was produced rapidly in the venom glands. There apparently was no misidentification of the offending milked reptiles, since all recently milked snakes are kept in a separate pen. The persons who milked the snakes were experienced and one may presume they extracted most of the venom. However, one would not expect as complete stripping of the venom glands during a lecture when the milking is done rapidly as would be obtained during careful laboratory work. Minton (1953) found the venom glands of timber rattlers and copperheads examined 24 hours after milking contained only a small amount of venom. On the other hand, Allyn (1937) estimated that timber rattlesnakes produced enough venom to kill a rat a day for five days. Actually, little is known about the physiology of venom glands. Until studies are made of the amount of venom produced daily, the mechanism of envenomation from recently devenomized snakes will remain a matter for speculation. Regardless of the mechanism, it is important to note that bites from recently milked snakes may prove dangerous.

Case reports 2 and 3 represent an example of repeated venomous snakebites in the same individual: these bites occurred three months apart. This case study points to a lack of permanent immunity produced by repeated pit viper bites. The patient should have had a high antibody titer from his first bite which theoretically should have protected him during his second envenomation. Watt, et al (1956) and Parrish and Pollard (1957) from a study of clinical histories found that patients with repeated pit viper bites do not exhibit evidence of permanent immunity. Criley and Hohenadel (personal communication) confirmed this clinical impression by venom neutralization tests in mice with the serum from snakebite patients.

A word on the industrial medical aspects of caring for employees exposed to the risk of venomous snakebites seems in order. All employees are required to wear snake-proof boots and long trousers while in the milking pen. They must report every venomous snakebite regardless of its seriousness. Each individual is tested for sensitivity to horse serum, so that antivenin may be administered without delay in case of a snakebite. Specific antivenins for all the venomous snakes handled at the Institute are kept in stock at all times. Each employee who handles venomous snakes receives a scratch test for allergy to pit viper venom. Results from scratch tests on 13 employees and former employees showed that 5 of these individuals were hypersensitive to pit viper venom. Parrish, Watt, and Arnold (1957) reported two of these cases of hypersensitivity, and described a method for performing venom-allergy scratch tests. It is conceivable that death might result from anaphylaxis due to allergy to snake venom, hence it would be useful for a physician to know if the patient was allergic. In this event, Cortisone, epinephrine, or antihistamines might be life saving.

Literature Cited

Allyn, W. P. 1937. Studies on poisonous snakes of Indiana. *Proc. Ind. Acad. Sci., 46: 220–24.*

MINTON, SHERMAN A. 1953. Variation in venom samples from copperheads (*Agkistrodon contortrix mokeson*) and timber rattlesnakes (*Crotalus horridus horridus*). COPEIA, *1953 (4)*: *212–15*.

PARRISH, HENRY M., AND C. B. PALLARD. 1957. The effects of repeated poisonous snakebites in man: A report of twelve cases. *Bull Ayer Clinical Laboratory, in press.*

PARRISH, HENRY M., HARRY F. WATT, AND JAMES D. ARNOLD. 1957. Human allergy resulting from North American snake venoms: A report of two cases. *Journal Florida Medical Assn., in press.*

WATT, HARRY F., HENRY M. PARRISH, AND C. B. POLLARD. 1956. Repeated poisonous snakebites in the same patient: An unusual case report. *North Carolina Med. Jour., 17: 174–79.*

WOOD, JOHN T., WILLIAM W. HOBACK, AND THOMAS W. GREEN. 1955. Treatment of snake venom poisoning with ACTH and Cortisone. *Virginia Medical Monthly, 82: 130–35.*

DEPARTMENT OF PUBLIC HEALTH AND PHYSICIAN, DEPARTMENT OF UNIVERSITY HEALTH, YALE UNIVERSITY SCHOOL OF MEDICINE, NEW HAVEN, CONNECTICUT AND MUNROE MEMORIAL HOSPITAL, OCALA, FLORIDA.

The Comparative Effects of Fresh-Water and Marine Teleost Pituitary on the Water Balance of Frogs[1]

GEORGE F. WEISEL

THE neurohypophysis affects the water metabolism of mammals and amphibians, but with the exception of inconclusive investigations by Burgess, Harvey and Marshall (1933), Boyd and Dingwall (1939), Fontaine (1956) and Smith (1956), the possible action of the pituitary in osmoregulation of fish has received scant attention, although it has been demonstrated that pituitary glands from fish cause amphibians to retain water (Heller, 1941; 1950).

The osmotic concentration of the blood and tissue fluids of fresh-water fish is in all cases higher than the external environment. Marine teleosts, on the other hand, have an osmotic concentration lower than that of ocean water (Krogh, 1939: 132, 138). Therefore, if the neurohypophysis does aid in the uptake or retention of water in teleosts, it seems plausible that marine species need produce a more potent type or a greater amount of the water retention factor than fresh-water species. Indirect evidence for this may be had by testing sensitive amphibians with pituitaries from marine and fresh-water fish.

The object of this investigation is limited to a comparison of gross weight changes induced in frogs by acetone-extracted whole pituitaries from marine and fresh-water teleosts. It does not include a distinction between anti-diuretic action and increased water absorption through the skin; nor is it concerned with whether more than one pituitary hormone is active. The effect of neurohypophysial extracts on amphibian water economy has been thoroughly treated by Jorgensen (1950).

MATERIALS AND METHODS

Whole fish pituitaries were ground in a mortar, extracted with acetone, air dried, and then ground to a fine powder with Ten Brock tissue grinders. Pituitaries of marine teleosts were taken from barracuda (*Sphyraena argentia*), white sea bass (*Cynoscion nobilis*), and yellowfin tuna (*Neothunnus macropterus*). As only a few glands were available from sea bass and tuna, these were lumped together to derive sufficient extract for an experiment. Pituitaries of fresh-water fish came from squawfish (*Ptychocheilus oregonense*) and longnose sucker (*Catostomus catostomus*). One barracuda pituitary was equivalent to 4.2 mg. of the desiccated material and one sucker gland to 2.7 mg. Weights of the fish were not obtainable so it was impossible to accurately correlate the size of the fish with the weight of the gland. This information by itself would be of little value as the relative sizes of the lobes of the gland and the rates of secretion are unknown. However, it was obvious from gross observation that the

[1] Supported by a grant from the Stella Duncan Memorial Fund, Montana State University.

ratio of the dry weight of the sucker pituitary to total body weight was greater than that of barracuda.

Portions of cerebellum and medulla oblongata from these fish were treated in the same fashion as the glands and used on the principal group of controls. Other controls received 1 cc. Ringer's solution or were untreated.

All extracts were administered to the frogs (*Rana pipiens*) by suspending the powder in 1 cc. Ringer's solution and injecting this into the dorsal lymph sac. The amount of desiccated powder administered and the number of animals tested are stated in the results. Experimental conditions and procedures were similar to those of Lazo-Wasem and Weisel (1952).

Weight changes were figured on a percentage basis and analyzed statistically by the Statistical Laboratory of Montana State University.

Results

To establish an appropriate dose the first tests were made with 1, 2, 3, and 4 mg. of barracuda and sucker pituitary, and a set of controls received equivalent amounts of brain. Sixty test animals were used, five for each dosage. Weighings were made at intervals over a period of 36 hours, at which time the majority of the animals had returned to their original weights. Frogs injected with 3–4 mg. pituitary extracts exhibited a greater weight gain than those that received 1–2 mg. The controls remained close to weight fluctuations of untreated frogs. Two mg. of either kind of pituitary extract induced large weight gains and appeared to allow the animals to return to their normal weight in reasonable time, 24–30 hours.

The weight changes produced by different amounts of barracuda pituitary as compared to sucker pituitary were analyzed statistically by the rank sum test (Table I). Except where the differences are insignificant, the barracuda extract caused a greater weight increase than sucker extract. This test also indicated that 1 or 2 mg. would be the best level to use in subsequent experiments. The 2 mg. dose was arbitrarily chosen. Larger doses incited a near maximal response by the frogs so that any differences in degree of reaction to the two extracts were not as evident.

TABLE I

Significance of greater weight gain of frogs injected with from 1–4 mg. of marine teleost pituitary (barracuda) compared with frogs that received the same amount of fresh-water teleost pituitary (sucker). Tested by the rank sum test (Wilcoxon, 1945).

Hours after injection	Amount of gland injected			
	1 mg.	2 mg.	3 mg.	4 mg.
2	Insignificant	Insignificant	Insignificant	Insignificant
6	$.05 > P > .02$	$.05 > P > .02$	Insignificant	Insignificant
10	$P < .01$	$.05 > P > .01$	Insignificant	Insignificant
14	$.05 > P > .02$	$P < .01$	$P < .03$	$.05 > P > .02$
24	$P < .05$	$P < .01$	$.02 < P < .03$	$.05 > P > .02$
30	Insignificant	Insignificant	Insignificant	$.05 > P > .02$
36	Insignificant	Insignificant	Insignificant	Insignificant

Forty-five frogs were injected with 2 mg. barracuda pituitary extract, 43 with sucker pituitary extract, 35 with brain extract (cerebellum and medulla), and 10 with saline solution alone. After the initial weighing, weights were taken at 2, 6, 10, 14, and 24 hours. The maximum weight gain occurred at six hours. At this time the averages and ranges of percent weight change were 34.2 (15.5 to 57.9) for animals injected with barracuda pituitary, 19.4 (1.6 to 40.6) for sucker pituitary, −0.3 (−11.5 to 5.8) for brain, and −0.2 (−6.1 to 5.0) for saline. After twenty-four hours the averages and ranges were 13.4 (−6.8 to 30.3) for barracuda pituitary, −2.4 (−17.2 to 5.6) for sucker pituitary, −2.9 (−12.0 to 13.2) for brain, and −0.4 (−6.6 to 6.4) for saline. A graphical analysis (Fig. 1) shows that at two hours the frogs that received barracuda and sucker pituitary were heavier than controls but not significantly different from each other. In all subsequent weighings the animals treated with barracuda glands were heavier than those treated with

sucker material. By fourteen hours the frogs injected with sucker pituitary had nearly returned to their original weight, whereas those injected with pituitary from barracuda remained heavier than controls at twenty-four hours. The statistical significance of the greater and more protracted weight gain caused by extracts from the marine fish as compared to extracts from the fresh-water fish is shown by maximum absolute deviate tests (Tables II and III).

There were only enough pituitary glands available from squawfish to treat seventeen frogs with 2 mg. each. With this group, twenty-two other animals were injected with a mixture of tuna and sea bass pituitary and

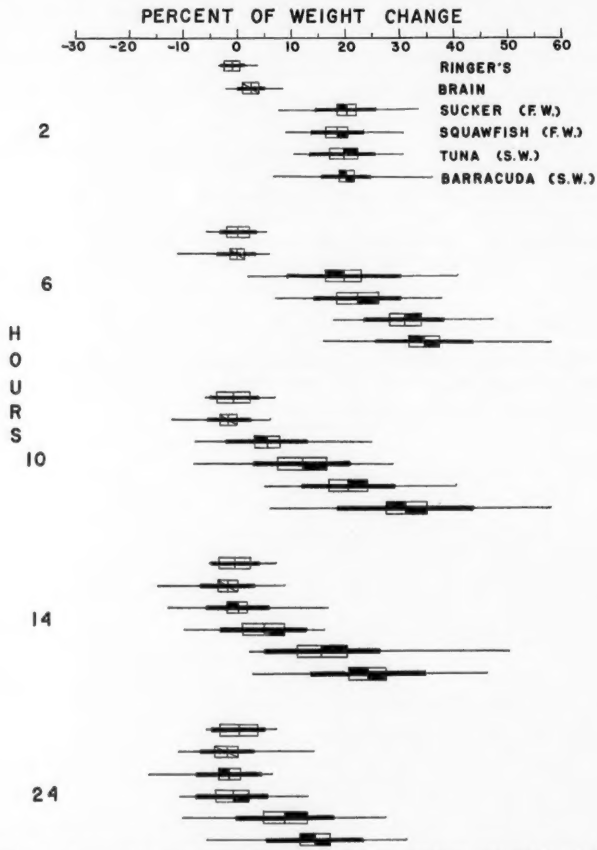

Fig. 1. Graph of percent weight changes of frogs. Comparisons are made of frogs injected with Ringer's solution alone, extracts of fish brain, extracts of sucker pituitary, squawfish pituitary, a mixture of tuna and sea bass pituitary, and barracuda pituitary. The sucker and squawfish are fresh-water teleosts; the tuna, sea bass, and barracuda are marine. The range of each group is depicted by the length of the light line, the mean is shown by a crossbar, the rectangle marks off two times the standard error on each side of the mean, and the heavy line extends for one standard deviation on each side of the mean (after Hubbs and Perlmutter, 1942).

ten with brain. Much the same results were obtained as in the previous experiment—glands from the marine fish induced a stronger and more lasting effect than material from the fresh-water fish. The differences, however, were not as srtiking. The tuna-bass extracts were not so potent as extracts from barracuda, and extracts from squawfish were

stronger than those from suckers. After six hours the averages and ranges of weight change were 30.6 (17.2 to 47.0) for frogs treated with tuna-bass pituitary, and 22.0 (6.7 to 37.6) for those with pituitary from squawfish. After twenty-four hours the calculations were 7.9 (−11.2 to 26.8) for the former group and −1.8 (−11.5 to 12.2) for the latter. The data from this experiment are combined with the barracuda and sucker experiment and presented in Figure 1 and Tables II and III.

TABLE II

Comparative weight change of frogs injected with 2 mg. of teleost brain (cerebellum and medulla), sucker pituitary, squawfish pituitary, tuna-sea bass pituitary, barracuda pituitary, and with Ringer's solution alone. Data from all but the first experiment are combined here.

Tested by the maximum absolute deviate test (Halperin et al, 1955). This test not only detects lack of non-homogeneity of weight gains, but the source of non-homogeneity. For instance line 1 indicates that the squawfish extracts cause a greater weight gain than Ringer's and brain at the level of significance of $P < .01$; and sucker, barracuda and tuna extracts a weight gain over that of squawfish at the same level of significance.

Hours after injection	Level of significance	Low gain	Medium gain	High gain
2	$P < .01$	Ringer's Brain	Squawfish	Sucker Barracuda Tuna
6	$P < .01$	Ringer's Brain	Sucker Squawfish	Barracuda Tuna
10	$P < .01$	Ringer's Brain Sucker	Squawfish	Barracuda Tuna
14	$P < .01$	Ringer's Brain Sucker	Squawfish	Barracuda Tuna
24	$P < .01$ except for squawfish which is $.05 > P > .01$	Brain Sucker Squawfish	Ringer's	Barracuda Tuna

As the anti-diuretic effects diminish, diuresis increases. This was noticeable in the amount of urine which could be expressed from pituitary treated animals after fourteen hours. Jorgensen (1950) noticed and measured the same phenomenon. After return to normal weight, test animals frequently exhibited a further loss to below their normal fluctuations. Frogs subjected to fresh-water fish pituitary fall to a lower weight in twenty-four hours than the saline injected controls (Table II).

DISCUSSION

It is evident that similar amounts of whole pituitary extracts from barracuda and a mixture from tuna and sea bass elicit a greater water gain in frogs than extracts from squawfish and suckers. The first three fish are marine and the other two are freshwater. If the neurohypophysis aids in teleost water economy, this difference in potency is in accordance with their opposite osmoregulatory needs.

TABLE III

Comparative weight change of frogs injected with 2 mg. fresh-water teleost pituitary (sucker and squawfish) and with marine teleost pituitary (tuna-sea bass and barracuda). This is from the same data used in Table II except the controls are excluded. Tested by the maximum absolute deviate test (see Table II).

Hours after injection	Level of significance	Low gain	Medium gain	High gain
2	Insignificant	—	—	—
6	$P < .01$	Sucker	Squawfish Tuna	Barracuda
10	$P < .01$	Sucker	Squawfish Tuna	Barracuda
14	$P < .01$ except for squawfish which is $.05 > P > .01$	Sucker Squawfish	Tuna	Barracuda
24	$P < .01$	Sucker Squawfish	Tuna	Barracuda

In conjunction with this assumption, the comparative effect of posterior pituitary extracts on different amphibian species is of interest. Steggerda (1937) found that on the administration of pituitrin, toads gained 45 percent in weight, two species of frogs gained 14 and 18 percent, and a urodele only gained 4 percent. The toad, being the most terrestrial in habits, has the most need to conserve water, while the urodele is an obligatory water dweller. Jorgensen (1950) has demonstrated that toads are much more sensitive to amphibian neurohypophysis than frogs. Furthermore, when injected with the same amount of pituitrin, the aquatic larval stage of the toad, *Bufo bufo*, responded weakly to

posterior pituitary extracts, but the metamorphosed toad exhibited a pronounced weight increase (Howes, 1940). However, there are other investigations which do not show a clear relation between response to pituitary and the ecology of the amphibian (Belehradek and Huxley, 1927; Novelli, 1933).

Also it is perhaps significant that the pituitary of marine teleosts contains more amphibian water balance principle than does the pituitary of elasmobranchs (Heller, 1950). The marine elasmobranchs do not require the active conservation of water since, due to the retention of urea in their blood and tissues, they are nearly poikilosmotic.

The few experiments concerned with the effect of the neurohypophysis on water economy of teleosts are inconclusive. Burgess, Harvey and Marshall (1933) tested the antidiuretic action of pitressin on *Ameiurus nebulosus*, a freshwater catfish. The urine flow was not affected by 0.2 to 2.0 units of the hormone. Extrarenal effects were not considered. However, these investigators did not detect an antidiuretic action when they tested frogs (*Rana catesbiana*), but Jorgensen has shown that Pitupartin AB and Insipidin AB have both a renal and cutaneous effect on *Rana temporaria* and *Bufo bufo*. Boyd and Dingwall (1939) administered pituitrin to shiners (*Notropis cornutus*), catfish (*Ictalurus lacustris*), perch (*Perca flavescens*), sunfish (*Lepomis gibbosus*), and rock bass (*Ambloplitis rupestris*). By weighing the fish at intervals for forty-eight hours, they could not demonstrate that pituitrin had any effect upon the total water content in the body of these fish. By a different approach, Smith (1956) also had negative results. He found that mammalian posterior lobe extracts did not augment the salinity tolerance of *Salmo trutta*.

Some of the more recent experiments indicate that the pituitary does play a role in regulating the water metabolism of teleosts, although it may not be similar to the amphibian mechanism. For instance, pitressin prevented sodium loss from the gills of goldfish and was accompanied by an increased urine production (Sexton, 1955). Hypophysectomy resulted in the inability of *Fundulus* to survive in fresh water. Replacement therapy with *Fundulus* pituitary enabled them to survive and pituitaries of *Perca flavescens* were partially effective, but extracts from a marine species had no beneficial influence (Burden, 1956). Also, through studies of neurosecretory material from the hypothalamo-neurohypophyseal system, evidence is accumulating that the system is affected by salinity changes (Arvy, Fontaine, and Gabe, 1954; Rasquin and Stoll, 1955). An excellent summary of the osmoregulatory functions of the fish pituitary is presented by Pickford and Atz (1957: 166–174).

Summary

This investigation indicates that pituitary extracts from marine teleosts are more potent and longer lasting in causing water retention in frogs than are equal amounts of extracts from freshwater fish. The difference in potency may be related to the necessity marine teleosts have in retaining water against a hypertonic environment.

Literature Cited

Arvy, L., M. Fontaine, and M. Gabe. 1954. Action des solutions salines hypertoniques sur le système hypothalamo-hypophysaire chez *Phoxinus laevis* Agass. et chez *Anguilla anguilla* L. *C. R. Soc. Biol., Paris, 148: 1759–61.*

Belehradek, J., and J. S. Huxley. 1927. The effects of pituitrin and of narcosis on water-regulation in larval and metamorphosed *Amblystoma. Brit. Jour. Exper. Biol., 5: 89–96.*

Boyd, E. M., and M. Dingwall, Jr. 1939. The effect of pituitary (posterior lobe) extract on the body water of fish and reptiles. *Jour Physiol., 95: 501–7.*

Burden, C. E. 1956. The failure of hypophysectomized *Fundulus heteroclitus* to survive in fresh water. *Biol. Bull., Woods Hole, 110: 8–28.*

Burgess, W. W., A. M. Harvey, and E. K. Marshall, Jr. 1933. The site of the antidiuretic action of pituitary extract. *Jour. Pharmacol. Exper. Therap., 49: 237–49.*

Fontaine, M. 1956. The hormonal control of water and salt-electrolyte metabolism in fish. *Mem. Soc. Endocrinol., 5: 69–81.*

Halperin, M., S. W. Greenhouse, J. Cornfield, and J. Zalokar. 1955. Tables of percentage points for the studentized maximum absolute deviate in normal samples. *Jour. Amer. Stat. Assoc., 50: 185–95.*

Heller, H. 1941. Differentiation of an (amphibian) water balance principle from the anti-diuretic principle of the posterior pituitary gland. *Jour. Physiol., 100: 125–41.*

Heller, H. 1950. The comparative physiology of the neurohypophysis. *Experientia, 6: 368–76.*

Howes, N. H. 1940. The response of the water-regulating mechanism of developmental stages of the common toad, *Bufo bufo* (L.), to treatment with extracts of the posterior lobe of the pituitary body. *Jour. Exp. Biol., 17: 128–38.*

Hubbs, C. L., and A. Perlmutter. 1942. Biometric comparison of several samples, with

particular reference to racial investigations. *Amer. Nat., 76: 528–92.*
JORGENSEN, C. B. 1950. The amphibian water economy, with special regard to the effect of neurohypophyseal extracts. *Acta. Physiol. Scandinavica, 22, suppl. 78: 1–79.*
KROGH, A. 1939. Osmoregulation in aquatic animals. *Cambridge at the Univ. Press, Cambridge.*
LAZO-WASEM, E. A., AND G. F. WEISEL. 1952. The comparative effects of fish and beef pituitary on retention of water by frogs. *Biol. Bull., Woods Hole, 102: 25–29.*
NOVELLI, A. 1933. Extrait postéro-hypophysaire et imbibition des batraciens. *C. R. Soc. Biol., Paris, 112: 506–7.*
PICKFORD, GRACE E., AND J. W. ATZ. 1957. The physiology of the pituitary gland of fishes. *N. Y. Zool. Soc., N. Y.*
RASQUIN, PRISCILLA, AND LOUISE M. STOLL. 1955. Effects of pitressin and water injections on the secretions of brain and hypophysis in a teleost. *Anat. Rec., 122: 452–53.*
SEXTON, A. W. 1955. Factors influencing the uptake of sodium chloride against a diffusion gradient in the goldfish gill. Ph. D. Dissertation, *Univ. Missouri. Diss. Abstr., 15: 2270–1.*
SMITH, D. C. W. 1956. The role of the endocrine organs in the salinity tolerance of the trout. *Mem. Soc. Endocrinol., 5: 83–98.*
STEGGERDA, F. R. 1937. Comparative study of water metabolism in amphibians injected with pituitrin. *Proc. Soc. Exper. Biol. and Med., 36: 103–5.*
WILCOXON, F. 1945. Individual comparisons by ranking methods. *Biometrics, 1: 80–3.*

DEPARTMENT OF ZOOLOGY, UNIVERSITY OF MONTANA, MISSOULA, MONTANA.

A Kansas Drouth Recorded in Growth Zones of a Bullsnake

FRANK E. PEABODY

POIKILOTHERMIC fishes and tetrapods living in the summer-winter seasons of temperate climate may develop annual growth zones in various regions of the bony tissues. During a study of the phenomenon (surprisingly widespread) in living and fossil poikilotherms I discovered that a specimen of a bullsnake, *Pituophis catenifer sayi,* from Kansas, possessed in addition to well developed annual zones, evidence of subnormal annual growth coinciding with a known period of severe drouth.

Pertinent details of the appearance, validity and utility of annual growth zones have been described in snakes of the southern Ukraine by Bryuzgin (1939) and in *Natrix natrix* of France by Petter-Rousseaux (1953). In these snakes, broad growth zones of opaque, whitish bone separated by narrow, transparent (or transluscent) zones appear most clearly in the ectopterygoid bone under transillumination, giving a banded pattern. The narrow, transparent zones represent a period of little or no growth during the winter, and constitute the rings, or annuli, of most studies of growth zones.

The bullsnake is an adult (skull 28 mm. long, from premaxillary to basioccipital) taken 6 miles west of Scott City in western Kansas, September 3, 1931, by Dr. Claude Hibbard. The skeletonized specimen is 2377 in the osteological collection of the Department of Zoology, University of California, Los Angeles (through the courtesy of Dr. Hibbard).

Several bones of the bullsnake mutually preserve zones representing an excellent annual record of approximately 11½ years. As in the European snakes described by Bryuzgin and Petter-Rousseaux, the ectopterygoid of the bullsnake preserves excellent zones. However, in the bullsnake the squamosals have an even better record in certain respects (Plate I). An abbreviated series of growth zones appear on the expanded, quadrate process of the pterygoid, and on the palatine and surangular. Growth zones also occur in polished thin sections taken through such bones as the maxillary and dentary. Surface zones of the squamosal and ectopterygoid, observed under xylene immersion, are the most complete and will be described first. Combinations of transmitted and reflected light were employed in these observations. Variations in lighting are usually necessary to see the full record preserved on a bone surface or section. Thus any single photograph will fail to illustrate all growth zones seen by the eye. Obvious caution must attend any study of growth zones thought to be annual in nature.

A matching series of 11 narrow winter zones and 12 broad, summer zones appears on the external surface of the squamosals. The zones seem to represent a continuous record of the last 11½ years of life; the focus of bone formation (Plate IB), evident under high transillumination, corresponds reasonably well with the amount of growth expected in the first growing season, thus the total age appears to be 11½ years. Significantly, the last summer growth zone is nearly completed, thus agreeing exactly with the time of death, September 3, near the end of the summer growing season in Kansas. Zones are clearest and most simply developed on the lateral half of the squamosals. Winter zones on the median half of the squamosals show a tendency to become wider and to appear double, as if suggesting a small, local increment of growth following the regular growing season—perhaps the "Indian Summer" of late autumn or early winter. Significantly, there is no evidence of a small increment following the last growth zone terminated by death on September 3, a date well in advance of "Indian Summer".

The total pattern of zones here described can not be reasonably attributed to individual feedings unless it can be shown that an adult bullsnake takes prey only once or twice a year in its native state. It is possible that feedings may be reflected by minor increments noted within the more obvious annual zones. In any case, the growth zones here considered annual, are comparable not only to those of other snakes, but also to annual zones observed in various lizards, crocodiles, and in the amphibian, *Necturus*.

The broad summer zones of the squamosals diminish more or less uniformly in width following the second summer except for two growing seasons in the middle of the record which appear unusually narrow. At this point, corresponding to the 1925 and 1926 summers, a narrow summer zone is followed by a second summer zone so narrow and in part discontinuous that the adjacent winter zones of transparent bone are close enough to form a conspicuous, transparent band visible on both squamosals.

The paired ectopterygoids also have a matching record of growth zones corresponding fairly well with the squamosal record. There is a similar longevity record, and significantly, a record of two increments of deficient growth during midlife resulting in a conspicuous band of transparent zones representing 3 winter annuli close together (Plate IA). The second narrow summer zone is noticeably narrower than the first, as in the squamosal record. The normal summer zones are not as wide relative to winter annuli as in the squamosal record. The overall growth record in the ectopterygoid may be considered excellent, though not quite as graphic as that of the squamosal.

Distinct growth zones appear on the thin crest of the surangular and on the flat, median plate of the palatine; but here the series are abbreviated and represent partial records, not showing the early years, or the narrow summer zones of midlife.

Transverse sections taken from bones lacking a surface record of growth zones nevertheless preserve to a surprising degree the full record of longevity seen on the surface of the squamosals. A transverse section through the dentary, at the point where Meckel's groove becomes enclosed, exhibits a series of zones complicated by a secondary center of growth between the Meckelian canal and the dorsal, longitudinal, alveolar canal. A series of at least 8 opaque zones, somewhat obscure at the beginning, is evident in the laterodorsal quadrant of the section. Here, the labial alveolar wall which supports the teeth, is built up in such a manner that each successively younger lamina of bone extends farther dorsally than the next older lamina. Thus a pattern of easily counted steps results (especially well exhibited in several lizard genera at hand). A narrow series of at least 9 opaque zones is seen in the ventral region between Meckel's canal and the ventral surface of the dentary. Evidence of deficient growth in midlife is not demonstrable in these series.

A section taken through the small maxillary just anterior to the articulation with the lacrimal exhibits a series of concentric zones surprisingly clear considering the tiny size of the ovoid section (.7 mm. wide by 1.7 mm. high). The zones are concentric on the alveolar canal and most clearly demarcated on the labial side, particularly in the core of the lateral, alveolar ridge where the zones form a succession of acute angles. There appears to be little or no resorption and/or replacement of original bone. At least ten thin zones of close-spaced lacunae, obscure in the earliest layers, can be recognized by comparing all areas of the section. Comparisons with the squamosal-epipterygoid records and with similar observations made on other reptilian genera indicate that the thin zones of lacunae in the maxillary (and dentary) of the snake

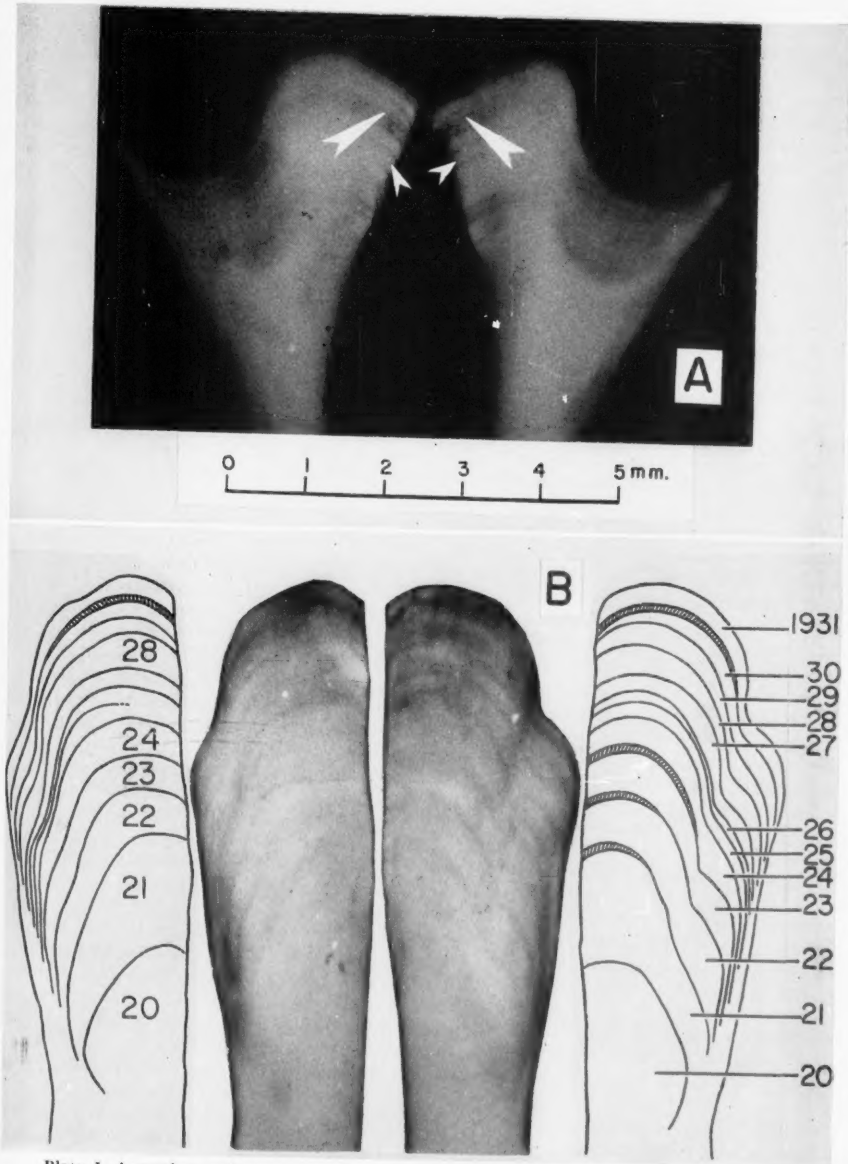

Plate I. Annual growth zones on the external surface of paired ectopterygoid bones (A) and squamosal bones (B) of the bullsnake from Kansas. Large arrows in A indicate narrow summer growth zone for 1926; small arrows indicate normal summer growth zone for 1923.

repre
narro
sal, n
tion
lacun
mate
dence
demo
in sec
Me
throu
zones
ness
occas
mens
Zone
of th
succe
main
zones
A
quad
show
close
seem
coun
of t
narro
and
more
secti
recor
it is
are
secti
Go
zone
face
goid
reaso
inac
tion
add
ditio
incr
incr
sepa
or r
mat
row
sum
zone
in t
tras
reco
peci
of s
Bry

represent annual increments. Evidence of the narrow zones of midlife, seen in the squamosal, may be represented in the maxillary section by the somewhat irregular zoning of lacunae at a point corresponding approximately to the 1925 annulus. This is poor evidence, in any case, but serves a point in demonstrating the limitations of growth zones in sections of at least small bones.

Median sagittal and transverse sections through two vertebrae exhibit a series of faint zones difficult to count, but in the total thickness of zones relative to the thickness of an occasionally distinct single zone, are commensurate with a minimum record of 10 years. Zones are clearest in the median ventral keel of the centrum and appear to correspond to successive layers of lacunae and to depend mainly on the latter for the contrast between zones, as in the maxillary.

A transverse section through the expanded quadrate process of the pterygoid (a bone showing surface zones at this point) exhibits close-spaced lacunae forming thin zones that seem to be clearly annual but difficult to count consecutively because of the thinness of the pterygoid process and the resulting narrow section. Presumably the squamosal and ectopterygoid would show internal zones more clearly, but these thin bones were not sectioned in order that their excellent surface record could be preserved intact. However, it is clear that surface zones described here are surface manifestations of zones seen in section.

Generally speaking, the correlation of the zones in the maxillary and dentary with surface zones on the squamosal and ectopterygoid is good enough to estimate the total age reasonably well, albeit not absolutely—the inaccuracy arising mainly through obliteration of early zones and probable failure to add annular increments under certain conditions. In the small maxillary, the smallest increments appear to be annual, and each increment is essentially characterized by a separate zone or layer of lacunae that may or may not be asociated with an opaque matrix. Where the two are associated, a narrow transparent zone intervenes between the summer growth zones and forms the winter zone. There is no doubt that annual growth in the bullsnake living in the strongly contrasting summer-winter climate of Kansas is recorded with a high degree of accuracy, especially when based on a comparative study of several bones of the skeleton. Whereas Bryuzgin (1939) and Petter-Rousseaux (1953) found that the epipterygoid preserved the best record in their European snakes, the squamosals of the bullsnake appear to have at least as good if not a better record.

Inasmuch as the bullsnake was known to have been killed in a specific year, 1931, the two summers of deficient growth during its midlife can be identified with reasonable accuracy as the summers of 1925 and 1926. There was the possibility that particularly severe, drouth-stricken summers may have been the causative factor involved. A check on national weather summaries (U. S. Department of Agriculture, Reports of the Chief of Weather Bureau from 1918 to 1931) and with the Chamber of Commerce of Scott City, Kansas, provides data of special interest.

Weather summaries for Dodge City, 65 miles southeast of Scott City, indicate that the summer of 1925 was severely hot and dry compared with several years preceding and following. The summer of 1926 was also relatively hot and dry. In 1925, the months of February, March and April were abnormally hot and dry in Kansas generally, and June temperatures averaged 4° higher than normal in Kansas, Texas and Oklahoma. The latter two states were extremely dry during June. In 1926, Kansas had a marked deficiency of moisture in May (and a serious drouth affected a vast region extending from Iowa south to Louisiana).

Available data from Scott City, 6 miles east of the home range of the bullsnake, consists of a *record of rainfall for the past 50 years compiled by Mr. Douglas Baker. Average precipitation for the six-month period presumed to encompass the maximum growing season, April through September, is as follows for the years 1920 to 1931: 1920, 2.27 inches; 1921, 1.85; 1922, 1.75; 1923, 5.13; *1924, 1.45; 1925*, 1.87; *1926, 1.85;* 1927, 3.06; 1928, 7.19; 1929, 2.47; 1930, 2.01; 1931, 2.09. Normal precipitation for the six-month period averages 2.44 inches. The years 1924 to 1926 are clearly below normal, and the cumulative effect probably was marked. These averages are well below the rainfall received 65 miles away at Dodge City which was also deficient for the same period.

There is no doubt that severe drouth conditions existed on the Great Plains generally, and in particular, in the immediate vicinity of Scott City, Kansas, during the summer growing season of 1924, 1925 and 1926. The two unusually narrow, growth zones on the squamosal of the bullsnake correspond to the

* Courtesy of the Scott City Chamber of Commerce.

summers of 1925 and 1926. There is the distinct probability that the narrow growth zones in the midlife of the bullsnake represent a crisis of some kind. A logical deduction is that the crisis was a shortage of animal food brought on by a combination of severe, drouthstricken summers which had a cumulative effect on the food supply in 1925 and especially in 1926. Also, excessive heat and aridity may have severely limited foraging activities of the usually *diurnal bullsnake. Thus a climatic crisis was brought to bear on the bullsnake primarily by affecting the food chain, specifically the rodent prey, e.g., *Microtus*, dependent upon summer vegetation, both wild and cultivated, and by affecting foraging activity. The combination of an unusually narrow, growth zone followed by a still narrower growth zone suggests that the possibility of disease or bodily injury might be considered, but the skeleton appears to have no abnormalities except for the evidence of the growth zones. It seems most likely that the deficiency in growth is a simple reflection of accumulative effects initiated by drouth conditions.

Clearly the annular zones seen in section do not lend themselves to discrete recordings of interrupted summer growth as do the growth zones appearing on the surface of the skull bones. Apparently the zones in section are too small and compact for reliable graphic illustration of interrupted summer growth, at least in the specimen at hand. Possibly a deficient growth period in the maxillary resulted in complete or nearly complete failure to form a new lamina of osteocytes. There seems to be no way to detect on such a small scale as the cross section of maxillary and dentary the growth record literally stretched out on flat bones of the skull. However, studies in progress indicate that the dentary of reptiles usually is the most consistent in preserving annual zones.

* Described by Smith (1950, p. 242) as a diurnal species. According to H. S. Fitch (personal communication) the species is largely crepuscular; therefore, the point made here is dubious.

It is concluded that the growth zones in the squamosal and ectopterygoid of the bullsnake are excellent indicators of age, and in this instance, also record faithfully a time of crisis in the life of the bullsnake occasioned probably by the severe drouth in Kansas in the summers of 1924, 1925 and 1926. Also there is the clear indication that annual growth zones may be developed in bones of the skeleton other than those exhibiting zones on the surface. These conclusions suggest interesting lines of study in the ecology of terrestrial poikilotherms, especially of the Great Plains. In this connection, discovery of annual zones in Pleistocene poikilotherms may be possible and highly informative. Current studies by myself reveal the occurrence of excellent annual zones in the dentaries of Australian lizards found in cave deposits of Pleistocene to Recent age.

Misses Hermine Newcombe and Madeline Peabody gave much appreciated assistance in the preparation of the manuscript and illustrations. Dr. Henry S. Fitch of the University of Kansas Natural History Reservation provided a helpful, critical reading of the manuscript.

Literature Cited

Bryuzgin, V. L. 1939. A procedure for investigating age and growth in Reptilia. *C. R. (Doklady) Acad. Sci. U.R.S.S. (N.S.), vol. 23, pp. 403–5, 4 figs.*

Petter-Rousseaux, A. 1953. Recherches sur la croissance et le cycle d'activité testiculaire de *Natrix natrix helvetica* (Lacépède). *Terre et Vie, 1953, pp. 175–223, 6 pls.*

Smith, H. M. 1950. Handbook of amphibians and reptiles of Kansas. *Univ. Kansas Mus. Nat. Hist., Misc. Publ. no. 2, pp. 1–336, 233 figs.*

Department of Zoology, University of California at Los Angeles, Los Angeles, California.

Pleistocene Lizards of the Cragin Quarry Fauna of Meade County, Kansas

Richard Etheridge

MANY important contributions to our knowledge of Pleistocene paleoecology and zoogeography of the Great Plains have been made by studies of vertebrate faunas recovered in southwestern Kansas and northwestern Oklahoma. The recovery and analysis of these faunas are due largely to the efforts of Dr. Claude W. Hibbard and sum-

mer field parties of the University of Michigan Museum of Paleontology. Most of the faunas are predominantly mammalian. No lizard remains have yet been recovered from any of those faunas which have been tentatively correlated with glacial advances (e.g. Dixon, Cudahay, Berends, Butler Springs, Jones, etc.). On the other hand, those faunas that have been correlated with the last two interglacial ages all contain at least some lizard remains. The Borcherds fauna (Yarmouth) lizards have not yet been carefully studied but appear to be predominately or entirely of the family Scincidae. From the Jinglebob fauna (Sangamon), Tihen (1954) has recorded *Holbrookia*, *Sceloporus* and *Eumeces*. Lizards from the Cragin Quarry fauna discussed in this report represent the largest Pleistocene lizard fauna yet recovered from southwestern Kansas. This fauna contains the same number of species that occur in that area today.

The Cragin Quarry lizards were collected during the summers of 1954, 1955 and 1956 by the University of Michigan Museum of Paleontology field party under the direction of Dr. Claude W. Hibbard. About 16 tons of matrix from the Cragin Quarry and one third of a ton from Mount Scott (Cragin Quarry horizon) were washed, using the techniques described by Hibbard (1949). Nearly 100 fragments of fossil lizards were recovered.

Cragin Quarry is located on the Big Springs Ranch in the southwestern quarter of section 17, T. 32 S., R. 28 W., 4 miles southwest of Meade, Meade County, Kansas. Mount Scott is about one-half mile south-southwest of Cragin Quarry in the southeastern quarter of section 18, T. 32 S., R. 28 W. The single fossil reported here from Mount Scott is from the Cragin Quarry horizon of that exposure. The matrix consists of silty and sandy clays deposited by a late Pleistocene stream that flowed into the early Cimarron River. The Cragin Quarry fauna is considered as occurring in the upper part of the Kingsdown formation, referred to the Sangamon interglacial of the Pleistocene. A discussion of the stratigraphic position of these deposits, in relation to the stratigraphic terms used by other authors, together with a survey of the history of collecting at this site, has been presented by Hibbard (1955: 189–90).

Lizard remains from the Cragin Quarry include vertebrae, limb bones, pelves, scapulocoracoids, dentaries, maxillaries, frontals, squamosals and parietals. All specimens are in the University of Michigan Museum of Paleontology (UMMP). Identifications are based on comparisons of the fossil remains with skeletons of recent North American lizards. Skeletons representing 28 genera and 61 species were examined during this study. Also available were topotypes of the five extinct lizards described by Talyor (1941) from the Rexroad fauna (Upper Pliocene) of Kansas. The nomenclature used is that of Schmidt (1953).

I am indebted to Claude W. Hibbard of the University of Michigan Museum of Paleontology for the privilege of studying these fossils and for permission to offer this report for publication. Dr. Hibbard has generously made available other fossil lizard material from the Museum of Paleontology collections for comparison with the Cragin Quarry fossils, and has offered valuable suggestions during the course of this study. I am grateful to Norman E. Hartweg of the University of Michigan Museum of Zoology for permission to use the extensive collection of recent lizard skeletons in the Division of Herpetology, and for his assistance in the preparation of this work for publication. I also wish to thank John Legler of the University of Kansas Museum of Natural History for the loan of recent *Cnemidophorus* skeletons, Bayard H. Brattstrom of Adelphi College for providing me with information concerning a specimen in the United States National Museum, and Ralph Axtell of the University of Texas for his helpful correspondence concerning the comparative osteology of *Holbrookia* and *Uma*.

Iguanidae

Crotaphytus collaris Say

The modern genus *Crotaphytus* contains five species, of which two are known as Pleistocene fossils. *Gambelia wislizeni* (= *Crotaphytus wislizeni*) is known from the McKittrick Pits of Kern County, California (Brattstrom, 1953) and *Crotaphytus collaris* is known from Gypsum Cave of Clark County, Nevada (Brattstrom, 1954). Gilmore (1928) provisionally referred the median portion of a left dentary from the Pliocene Benson funa of Arizona to the genus *Crotaphytus*. The description and figure of this specimen given by Gilmore indicates that the fragment should not be referred to this genus or even to the family Iguanidae. The

fragment was described as having 10 pleurodont teeth which are subcylindric with slightly compressed crowns, anterior teeth simple and sharply pointed; median teeth unequally bicuspid; teeth inclined slightly backward. Iguanid lizards never have a long series of bicuspid teeth, the anterior simple series being followed immediately by tricuspid or multicuspid teeth or occasionally with one or two bicuspid teeth between the two series. The specimen may well be referrable to the teiid genus *Cnemidophorus* in which many species have a long series of bicuspid teeth. Brattstrom (*in litt.*) has informed me that the specimen (USNM 10690) is labeled *Cnemidophorus* and that he agrees with this determination.

Among the fossils from the Cragin Quarry are three maxillaries, seven dentaries, two scapulacoracoids, one vertebra and one pelvis

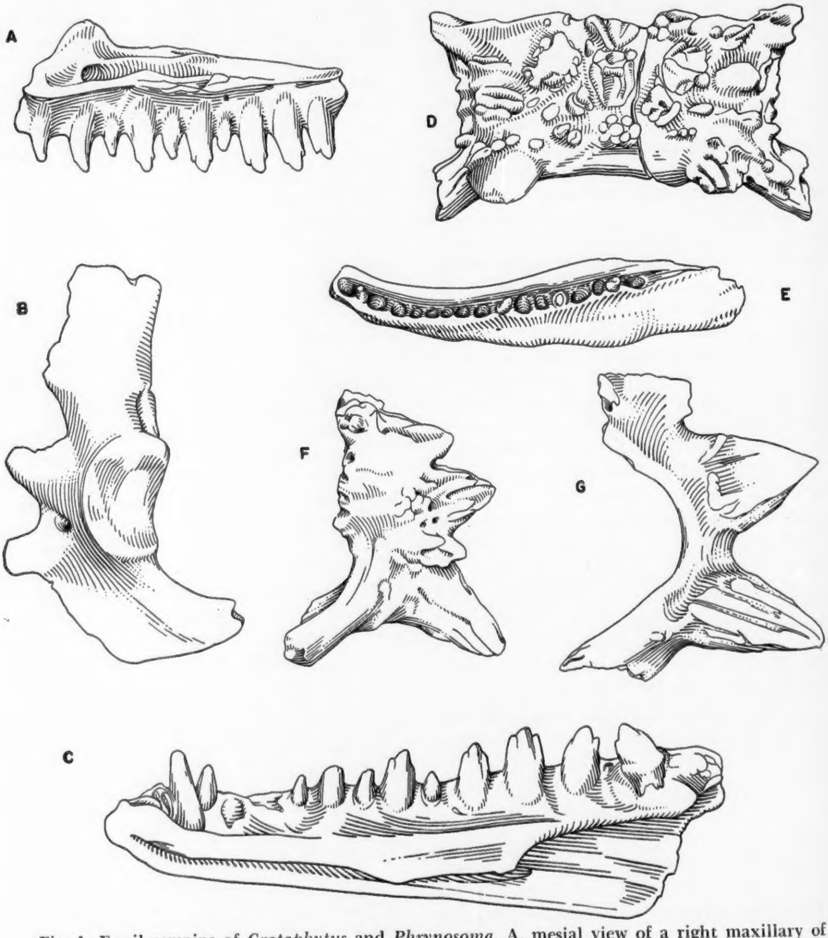

Fig. 1. Fossil remains of *Crotaphytus* and *Phrynosoma*. A, mesial view of a right maxillary of *Crotaphytus collaris* (UMMP No. 34132). B, right scapulacoracoid of *Crotaphytus collaris* (UMMP No. 33833). C, mesial view of right dentary of *Crotaphytus collaris* (UMMP No. 34138). D, dorsal view of parietal of *Phrynosoma modestum* (UMMP No. 33827). E, dorsal view of left dentary of *Phrynosoma modestum* (UMMP No. 34146). F, squamosal of *Phrynosoma modestum* (UMMP No. 34141). G, squamosal of *Phrynosoma cornutum* (UMMP No. 34126). A, C and E times 8; B, D, F and G times 12. Illustrations are by Mrs. Bonnie Hall.

of *Crotaphytus collaris* (Fig. 1). These fossils have been compared with modern skeletons of *C. wislizeni, C. collaris,* and *C. reticulatus.* The dentary of *C. wislizeni* differs from that of *C. collaris* in being generally more slender, having the mental foramina more widely separated, in having the last mental foramen below the 14th tooth, in lacking the terminal expansion of the anterior part of the element, and in having the Meckelian groove closed anterior to the splenial for a space of about seven teeth. The teeth of *C. wislizeni* are slenderer, longer and more widely separated at their tips and the tricuspid teeth are transversely compressed at their bases instead of being round as is *C. collaris.* The dentary of *C. reticulatus* is more like that of *C. collaris* but differs in having the Mackelian groove closed anterior to the splenial for a space of about four teeth and in having only three mental foramina. The maxillary of *C. collaris* differs from that of *C. wislizeni* in that the premaxillary process is longer and heavier, the anterior border of the nasal process rises at a more acute angle from the premaxillary process, the dorsal border of the posterior process is not as strongly concave, the labial foramina are closer together and the teeth are shorter, closer together, more robust and not so sharply pointed nor transversely compressed at their bases. The postcranial elements of the three species are nearly identical. In those skeletal elements which are different in the three species, the fossils are clearly referrable to *C. collaris.* In view of this and the fact that the ranges of *C. reticulatus* and *C. wislizeni* are far removed from the Cragin Quarry site, all of the fossil specimens of *Crotaphytus,* both cranial and postcranial elements, are referred to the species *C. collaris.*

Referred Material: dentaries UMMP 34129, 33831, 34138, 34135, 34137, 34134 and 34122; maxillaries UMMP 34133, 34130 and 34132; scapulacoracoids UMMP 33833 and 34129; pelvis UMMP 33828; dorsal vertebra UMMP 34139.

Phrynosoma modestum Girard

Three extant species of this genus have been reported as fossils. *Phrynosoma orbiculare* is known from the Late Pleistocene of San Josecito Cavern, Mexico (Brattstrom, 1955b); *P. platyrhinos* from the Pleistocene of Gypsum Cave, Nevada (Brattstrom, 1954); *P. cornutum* from the Upper Pliocene of the Rexroad fauna, Kansas (Oelrich, 1954) and from the Late Pleistocene of Newton County, Arkansas (Gilmore, 1928). A single extinct form has been described, *Phrynosoma josecitensis* from San Josecito Cavern (Brattstrom, 1955b).

The Cragin Quarry fossils referred to this species (Fig. 1.) have been compared with recent skeletons of *P. modestum, P. cornutum, P. douglassi, P. platyrinos and P. coronatum.* The number, position and size of the head spines and the sculpturing on the lower jaw is usually reflected by underlying elements of the skull so that most cranial elements may be identified to species. The dentary of *P. modestum* differs from those of the other forms examined in many respects, the most striking of which is the greatly expanded and scalloped ventrolateral margin. With respect to this character, as near as it is possible to tell from an examination of the external aspect of the lower jaw, *P. modestum* differs from all other species in the genus. The maxillary of *P. modestum* is distinguished by well developed rugosities at the base of the anterior border of the nasal process and by the relatively smaller size of the anterior inferior alveolar foramina. The squamosal of *P. modestum* may be readily distinguished from those of other species by the size and position of the temporal spines. These spines are small, wide at their bases and pointed. Those of *P. douglassi* are smaller, rounded and more widely spaced; those of *P. cornutum* are much longer and more sharply pointed. In *P. modestum* the anterior spine is smallest and laterally directed, the central spine is intermediate in size and posteriolaterally directed, and the posterior spine is largest and directed caudad. The parietal of *P. modestum* differs from that of *P. cornutum* in having dorsal rugosities that are more numerous, and less sharply pointed, in having much shorter parietal spines, and in having on the posterior border well developed recesses which receive the spinalis dorsi muscles. The parietal of *P. modestum* differs from that of *P. douglassi* in having dorsal rugosities and shorter, heavier posteriolateral processes.

Referred Material: dentaries UMMP 34146 and 34145; parietal UMMP 33827; maxillaries UMMP 34144 and 34143; squamosals UMMP 34140, 34141 and 34142.

Phrynosoma cornutum Harlan

A single right squamosal from the Cragin Quarry is referred to this species. The temporal spines are large, pointed and directed more or less laterally. The central spine is the longest.

terglacial) has been questionably referred to *Holbrookia* by Tihen (1954). There are no other records of this genus in fossil form.

Ten dentaries, three maxillaries, three frontals and two pelves from Cragin Quarry are referred to *Holbrookia* and tentatively

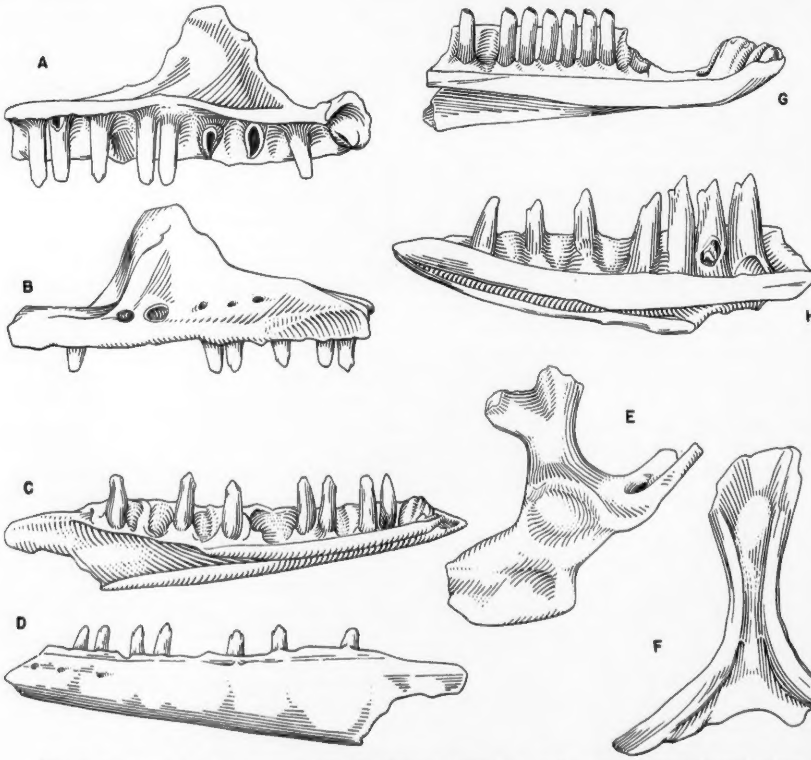

Fig. 2. Fossil remains of various Cragin Quarry lizards. A and B, mesial and lateral views of left maxillary of *Holbrookia cf. texana* (UMMP No. 34171). C and D, mesial and lateral views of left dentary of *Holbrookia cf. texana* (UMMP No. 34172). E, left half of a pelvis of *Holbrookia cf. texana* (UMMP No. 34165). F, ventral view of a frontal of *Holbrookia cf. texana* (UMMP No. 34556). G, mesial view of left dentary of *Eumeces obsoletus* (UMMP No. 34159). H, mesial view of a right dentary of *Cnemidophorus sexlineatus* (UMMP No. 34151). A, B, C, D, G and H times 12; E and F times 8.

Referred Material: squamosal UMMP 34126.

Several dorsal vertebrae and a single sacrum from Cragin Quarry belong to the genus *Phrynosoma*. These elements are so similar in the species examined that I am unable to determine the species to which they belong.

Holbrookia cf. texana Troschel

A single maxillary from the Jinglebob fauna of Kansas (Pleistocene, Sangamon in-

to the species *texana* (Fig. 2). Dentaries and maxillaries of *Holbrookia* may be distinguished from most other North American iguanids by their teeth. These elements most nearly resemble those of *Uma and Sceloporus*. The posterior dorsolateral face of the dentary (where the adductor mandibularis is attached) of *Holbrookia* is convex but flat or slightly concave in *Sceloporus*. The maxillaries of these two genera differ in that the lateral face of the posterior process ascends more steeply from the alveo-

lar margin in *Sceloporus* than in *Holbrookia.* Both maxillary and dentary differ from those of *Uma* in being smaller and in having fewer teeth. The pelvis of *Holbrookia* is similar to that of *Callisaurus, Uma* and *Crotaphytus* in that the preacetabular process is well developed but not produced anteriorly. The anterior and ventral borders of the process form a right-angle ridge bordering an excavation for the attachment of the M. iliotibialis. The pelvis of *Holbrookia* may be distinguished from that of *Uma, Callisaurus and Crotaphytus* by the absence of well marked sutures in the acetabulum.

Except by the larger adult size of *Holbrookia texana,* I am unable to distinguish recent skeletons of that species from those of *Holbrookia maculata.* Although *H. maculata* now occurs in southwestern Kansas and *H. texana* does not, the fossils of this genus are tentatively referred to the latter species because of their large size and the associated lizard fauna. Axtell (*in litt.*) has informed me that the caliche rubble substratum and associated lizard fauna indicate an environment characteristic of modern *Holbrookia texana* rather than of *H. maculata.*

Referred Material: dentaries UMMP 34167, 34175, 34174, 34173, 34172, 31678, 34170, 33375 and 34176: maxillaries UMMP 33832, 34171 and 34168; pelves 34167 and 34166; frontals UMMP 34451, 34452 and 34556.

TEIIDAE

Cnemidophorus sexlineatus Linneaeus

A nearly complete dentary and the anterior part of another are referred to this species (Fig. 2). The fossils have been compared with 13 species and subspecies representing all of the five species groups of this genus and with 11 topotypic specimens of the Kansas Pliocene form, *Cnemidophorus bilobatus* Taylor, 1941. The Cragin Quarry fossils are indistinguishable from *C. sexlineatus,* the only species of *Cnemidophorus* occurring in the region today.

According to Taylor (1941), *Cnemidophorus sexlineatus* differs from *C. bilobatus* in having more slender and somewhat more tapering, laterally compressed teeth with their bases closer together and the upper parts more widely separated. I may add that *C. bilobatus* also has a higher number of mental foramina, 9 to 10 in *C. bilobatus* and 5 to 7 in *C. sexlineatus.* Among the additional lizard fossils secured from the Rexroad fauna there are two nearly complete dentaries of *C. sexlineatus,* UMMP 34191 and 34192, as well as a number of other *C. bilobatus.*

Referred Material: dentaries UMMP 34152 and 34151.

SCINCIDAE

Eumeces obsoletus Baird and Girard

Fragments of two maxillaries, four dentaries, two sacra, one cervical vertebra and two dorsal vertebrae from Cragin Quarry are referred to this species (Fig. 2). the fossils have been compared with recent skeletons of *E. obsoletus, E. septentrionalis* and *E. fasciatus.* Both dentaries and maxillaries are similar in the three species but may be distinguished by the shape of their teeth. The teeth of *E. obsoletus* are more strongly compressed transversely than in the other two species. In addition, the crown is somewhat expanded laterally in *E. fasciatus* and *E. septentrionalis* whereas in *E. obsoletus* the tooth tapers uniformly to the tip. The fossil dentaries have been compared with topotypes of the Kansas Pliocene form, *Eumeces striatulatus.* The differences noted by Taylor (1941: 172) between *E. obsoletus* and *E. striatulatus* apply as well to the differences between *E. striatulatus* and the Cragin Quarry fossils. Although the postcranial elements of the species examined differ very little, the fossil postcranial elements are also referred to this species because of their large size.

PALEOECOLOGICAL IMPLICATIONS OF THE CRAGIN QUARRY LIZARD FAUNA

The Cragin Quarry lizard fauna is composed of species still living at the present time; thus, two types of data are available for paleoecological considerations, which are not normally available to the researcher working entirely or partially with extinct faunas. First, the extant ranges of the species under consideration are well known, and second, there is considerable information available concerning the habitats in which these species live and the environmental factors which control their distribution. By superimposing the extant ranges of the Cragin Quarry lizards, an area is delimited in which all forms except *C. sexlineatus* may be found today (Fig. 3). This area covers most of the desert plateau of northcentral México between the Sierra Madre Occidental and the western slopes of the Sierra Madre Oriental, as well as the semi-arid regions of southern New Mexico and Western Texas.

This area is entirely south of the present 50°F mean winter isotherm and for the most part within the present 90°F summer isotherm. This region has been characterized by Dice (1943) as being distinctly arid, with long, hot summers and short winters with only brief periods of below-freezing temperature. The spring and early summer are extremely dry and summer rains normally occur from July to October. Vegetation is composed of scrubby, thorny trees such as mesquite, creosote bush and yucca, with scattered short grass leaving wide areas of bare ground. The present climate of southwestern Kansas differs from the climate of the area outlined in figure 1, in having a lower annual temperature, a lower winter minimum but not a higher summer maximum, and somewhat higher mean annual precipitation. If the lizard fauna of the Cragin Quarry is a true reflection of the enviornment existing at the time that horizon was formed, then the climate and vegetation of the area outlined in figure 1 and characterized above, may be considered approximately that of the Cragin Quarry horizon.

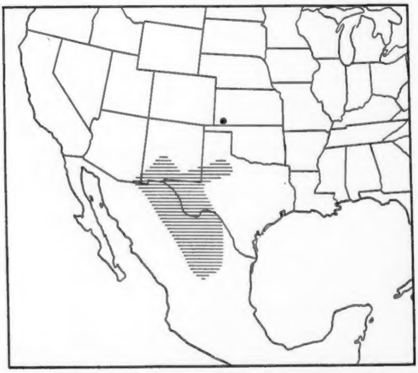

Fig. 3. Map showing the region where *Crotaphytus collaris, Holbrookia texana, Phrynosoma cornutum, Phrynosoma modestum* and *Eumeces obsoletus* now occur together (shaded area). The black dot in southwestern Kansas indicates the locality of the Cragin Quarry.

In addition to general climatic considerations, we may speculate on other aspects of Cragin Quarry local environment. For at least three of the lizard species, *Crotaphytus collaris, Holbrookia texana* and *Eumeces obsoletus,* exposed rocky outcrops and extensive areas of bare ground seem to be essential features of their habitat (Fitch, 1955, 1956 a and b; Jameson and Flury, 1949; Peters, 1951). Although *Phrynosoma,* especially *P. modestum,* is often found in rocky areas, exposed rock outcrops are probably not required. *Phrynosoma* does, however, share with the other three species a requirement for open areas with little or no vegetation. All of the lizards concerned spend considerable time basking in direct sunlight. None of the species is arboreal and extensive areas in which the ground is shaded most of the day, either by dense grass or close stands of trees or bushes, would be uninhabitable by any of the Cragin Quarry lizards.

The only species in the fauna that is characteristically found on sandy rather than rough, rocky ground, is *Cnemidophorus sexlineatus.* Although this species ranges widely over southeastern United States, it is restricted to localized areas of sparse vegetation and sandy soil where high precipitation is rendered less effective and more semiarid local conditions result. *Holbrookia maculata,* a species absent from the Cragin Quarry fauna but present in Meade County today, is found almost entirely on sandy soils. In contrast, *Holbrookia texana* is seldom found in sandy areas. The absence of *H. maculata* is difficult to explain, since the Cragin Quarry is located well within its present day range. Both *Holbrookia maculata* and *Cnemidophorus sexlineatus* characteristically show high population density wherever they occur, much higher than any of the other species except possibly *Holbrookia texana,* yet only two fragments of *C. sexlineatus* were recovered and none at all of *H. maculata.* Perhaps *Holbrookia maculata* did occur in southwestern Kansas at that time but local conditions were such that bare sandy areas on which *Holbrookia maculata* and *Cnemidophorus sexlineatus* occurred were too restricted or too distant to contribute much to the Cragin Quarry beds. From these considerations I would postulate that the Cragin Quarry local habitat was one of extensive areas of bare, rocky ground with occasional rocky outcrops, perhaps small, scattered patches of sand, and vegetation consisting of scattered clumps of short grass and low xerophilous shrubs.

The remaining species to be considered, conspicuous by its absence from the fauna, is the fence lizard, *Sceloporus undulatus,* common in southwestern Kansas and the immediate vicinity of the Cragin Quarry today. The local habitat constructed so far, from a consideration of the requirements of

the other species, is quite in agreement with the requirements of this lizard with one obvious exception, the presence of trees or bushes. Trees and bushes, if they are scattered, may occur within the habitats of the other species but are not essential features of their environment. On the other hand, *Sceloporus undulatus* is primarily an arboreal lizard, and since it is the only arboreal lizard expected but not found in the fauna, the absence of trees or bushes is implied.

Speculations concerning the paleoecological conditions of the Cragin Quarry have required that a number of assumptions be made for which there is little or no direct evidence, e.g., that populations of lizards in the Sangamon of southwestern Kansas were influenced by environmental factors in the same way as are contemporary populations of the same species today, that the absence of a lizard species in the fossils from the Cragin Quarry precludes the occurrence of that species in the Sangamon fauna and that the absence of a species from the fauna was a result of the same excluding factors that influence the species today. The paleoecological considerations presented here have been drawn from an analysis of the lizard fauna alone. A large number of vertebrate and molluscan remains have been recovered from the Cragin Quarry and as the study of these other faunal elements proceeds, a better picture of the Cragin Quarry local environment is to be expected.

Summary

About 100 fragments of fossil lizards have been recovered from the Cragin Quarry horizon of the upper part of the Kingsdown formation, referred to the Pleistocene, Sangamon interglacial, of Meade County, Kansas. Six extant species of lizards are identified: *Crotaphytus collaris, Holbrookia cf. texana, Phrynosoma cornutum, Phrynosoma modestum, Cnemidophorus sexlineatus* and *Eumeces obsoletus. Phrynosoma modestum* is here reported as a fossil for the first time. The fauna includes no extinct species of lizards. *Holbrookia texana* and *Phrynosoma modestum* do not now occur in southwestern Kansas but range to the south and west. *Sceloporus undulatus* and *Holbrookia maculata* occur in the area today but where not found as fossils.

An analysis of the lizard fauna, from the standpoints of present species distribution and habitat requirements suggests the local environment was somewhat different than that found in southwestern Kansas today, with a climate of less extreme winter temperatures and generally more arid conditions. The local habitat suggested is one of extensive areas of bare, rocky ground with occasional rock outcrops and perhaps small, widely scattered patches of sand. The vegetations possibly consisted of scattered clumps of short grass and low xerophilous shrubs.

Literature Cited

Brattstrom, B. H. 1953. Records of Pleistocene reptiles from California. Copeia, *(3): 174–9.*

——— 1954. Amphibians and reptiles from Gypsum Cave, Nevada. *Bull. So. Calif. Acad. Sci., 53: 1: 8–12.*

——— 1955a. Pliocene and Pleistocene amphibians and reptiles from southeastern Arizona. *Jour. Paleo., 29: 1: 150–4.*

——— 1955b. Pleistocene lizards from San Josecito Cavern, México, with description of a new species. Copeia *(2): 133–4.*

Dice, L. R. 1943. The biotic provences of North America. *Univ. Mich. Press, 1–78.*

Fitch, H. S. 1955. Habits and adaptations of the Great Plains Skink (*Eumeces obsoletus*). *Ecol. Monographs, 25: 59–83.*

——— 1956a. An ecological study of the collard lizard, *Crotaphytus collaris. Univ. Kans. Pub. Mus. Nat. Hist., 8: 3: 213–74.*

——— 1956b. Temperature response in free-living amphibians and reptiles of northeastern Kansas. *Univ. Kan. Pub. Mus. Nat. Hist., 8: 7: 417–75.*

Gilmore, C. W. 1928. Fossil lizards of North America. *Mem. Natl. Acad. Sci., XXII: 3: i–ix, 1–201.*

Hibbard, C. W. 1949. Techniques of collecting microvertebrate fossils. *Contrib. Mus. Paleo., Univ. Mich., 8: 2: 7–19.*

——— 1955. The Jinglebob interglacial (Sangamon ?) fauna from Kansas and its climatic significance. *Contrib. Mus. Paleo., Univ. Mich., 12: 10: 79–228.*

Jameson, D. L. and A. G. Flury 1949. The reptiles and amphibians of the Sierra Vieja range of southwestern Texas. *Tex. Jour. Sci., 1: 2: 54–77.*

Oelrich, T. M. 1954. A horned toad, *Phrynosoma cornutum,* from the Upper Pliocene of Kansas. Copeia *(4): 262–3.*

Peters, J. A. 1951. Studies on the lizard *Holbrookia texana* (Troschel) with descriptions of two new subspecies. *Occ. Pap. Mus. Zool., Univ. Mich., 537: 1–20.*

Schmidt, K. P. 1953. A checklist of North American reptiles and amphibians. *Univ. Chicago Press, pp. i–viii, 1–280.*

Taylor, E. H. 1941. Extinct lizards from the Upper Pliocene deposits of Kansas. *Univ. Kan. Pub. State Geo. Surv., Bull.* 38, *Rep. of Studies Part 5, pp. 165–76.*

Tihen, J. A. 1954. A Kansas Pleistocene herpetofauna. Copeia *(3): 217–21.*

Division of Herpetology, Museum of Zoology, University of Michigan, ann Arbor, Michigan.

Geographic Variations in Egg Complement of *Percina caprodes* and *Etheostoma spectabile*

Clark Hubbs

GEOGRAPHIC variation of fishes is well known, not only in gross morphology but also in physiologic (Hart, 1952) and genetic factors (Gordon and Gordon, 1954). Therefore, geographic variation in egg complements is to be expected. Katz (1948), Määr (1949), Simpson (1951), and Holloway (1954) published data that demonstrate such variation although Holloway did not comment upon this.

In connection with studies of survival rates of North American freshwater fishes and their hybrids (Hubbs and Strawn, 1956, and 1957a), egg complements of many species from various localities have been tabulated. For those species that have adequate data, geographic variation appears to be the rule. Therefore, application of egg counts of fishes in one stream system to total egg production in another, such as by Shapovalov and Taft (1954), may be hazardous. Data are presented on two darters, *Percina caprodes* (Rafinesque) and *Etheostoma spectabile* (Agassiz). These two species lay eggs several times during each spawning season (Strawn and Hubbs, 1956), as do other darters (Petravicz, 1936; Raney and Lachner, 1939; Fahy, 1954; and Hubbs and Strawn, 1957b). The number of eggs produced at one time by a female is chiefly controlled by her size (Fahy, 1954). The frequency of spawning is in large part controlled by water temperature (Hubbs and Strawn, 1957b).

Methods

Eggs were stripped from females following the technique given by Strawn and Hubbs (1956). The number of eggs adhering to the bottom were tabulated. As only mature eggs were counted, changes of egg number with stage of development (Vladykov, 1956) does not distort the comparisons. Since egg complements of equal sized females from a single population stripped on different dates are similar, seasonal changes in egg complement do not invalidate the data.

The egg counts here reported probably are slightly lower than maximal. Occasional eggs might not be expelled by stripping techniques. Part of a female's egg complement may have been spawned naturally. Females in poor condition lay fewer eggs than healthy females (Hubbs and Strawn, 1957b). However, as the number of eggs in a given sized female from a specific locality is approximately the same whether the eggs are stripped or laid naturally, the figures are considered relatively accurate. Moreover, as all counts of egg complements here reported are of stripped eggs, comparisons of the data are valid.

Egg Complement of *Percina caprodes*

Ripe females of *Percina caprodes* have been obtained from several localities. Moderately adequate data are presented (Fig. 1) for females from the Colorado River (19 specimens) in Travis County, Texas, and the Guadalupe River in eastern Kerr and western Kendall counties (16 specimens). Colorado River females produce more eggs at any given size than do females from the adjacent Guadalupe River. As eggs from Guadalupe River *Percina* are larger than those from the Colorado River females, egg volumes are approximately equal. A few females (notably the two 104 mm. Colorado River specimens, the 89 mm. Guadalupe River individual, and perhaps some small individuals) may have spawned some of their eggs before being stripped.

Egg Complement of *Etheostoma spectabile*

Ripe females of *Etheostoma spectabile* have been obtained from several localities. Median egg complements are given by length of the females (Fig. 2) for five populations: Guadalupe River in eastern Kerr and western Kendall Counties, Texas; Colorado River, Travis County, Texas; San Gabriel River, Williamson County, Texas; Brush Creek, Washington County, Arkansas; and a tributary to the Saline River, Washtenaw County, Michigan. Michigan females produce fewer eggs and Arkansas females more eggs than equal sized Texas females. Diameters of the Michigan eggs are almost twice those of Texas eggs and three times those of Arkansas eggs. Although the differences are less marked, Colorado River females average more eggs than equal sized Guadalupe River and San Gabriel River females. The few occasions where the median numbers cross can be attributed to sampling error. No correlation with latitude is apparent. The Colorado

River is geographically intermediate between the Guadalupe and San Gabriel, but extreme in egg number. Arkansas is between Michigan and Texas but the egg complements of *E. spectabile* females are extreme.

Data from laboratory reared and wild-captured *E. spectabile* females from Guadalupe River stocks do not differ so the egg numbers are presumed to be controlled by genetic factors.

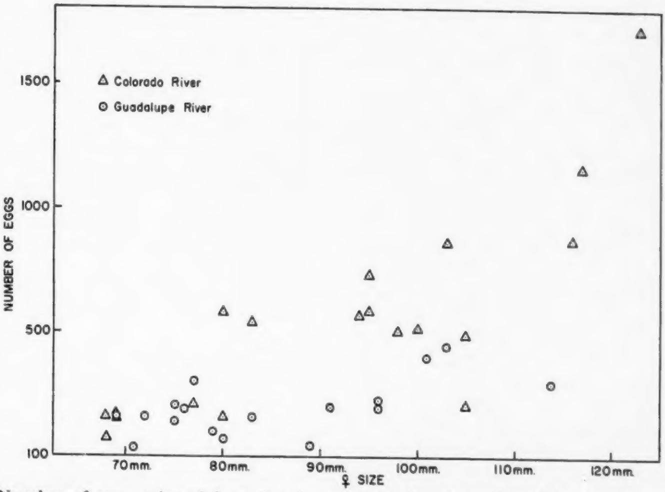

Fig. 1. Number of eggs stripped from *Percina caprodes* females collected in the Colorado and Guadalupe rivers, Texas.

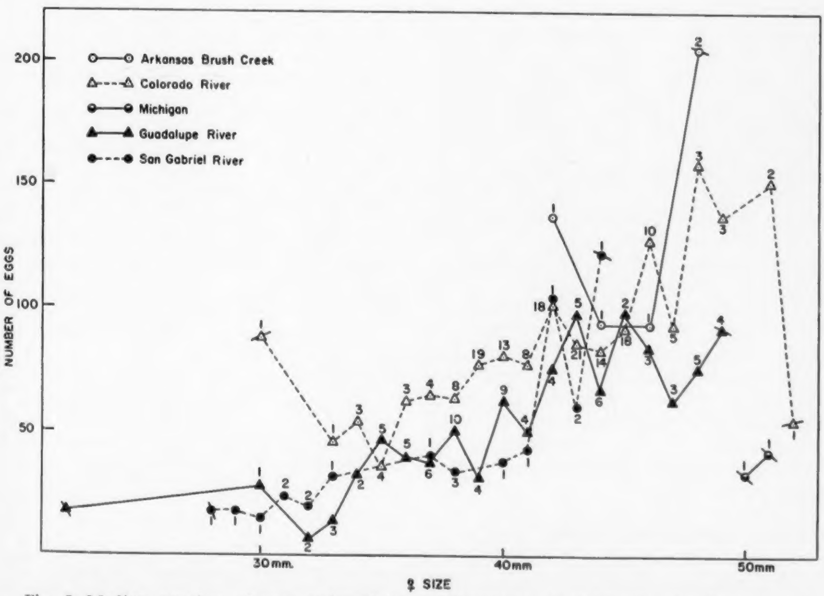

Fig. 2. Median number of eggs stripped from *Etheostoma spectabile* females from several populations. Average between two median numbers is given if there is an even number of specimens of a given millimeter. The number of specimens is adjacent to the appropriate symbol.

Significance of Egg Number

An increase in the number of eggs raises the number of individuals potentially able to survive. The number of eggs produced at one time by a given female is in large part a produce of her size and egg diameter (Svärdson, 1949). Either the female must grow and use food material for growth or she must produce smaller eggs. Smaller eggs may in turn have reduced individual survival.

Moore (1942) correlated frog egg sizes with latitude. He reported that eggs of northern species were larger than those of their southern relatives. As a result northern frogs could more nearly complete the hazardous larval stages using yolk as their food source. Later (1949) he reported similar results within one species, *Rana pipiens* Schreber, in the United States. Eggs from Mexican frogs did not fit the cline as they were the largest reported by Moore. He suggested that other selective forces promoting large egg size in Mexican frogs counteracted the selective action of high temperatures there.

I agree with Svärdson's and Lack's (1954) thesis that egg size is chiefly a result of food supply over the past several centuries. Likewise, temperature might significantly affect egg size. Rapid completion of larval stages would be advantageous in cold regions with a short growing season. Increased food supply from the yolk would insure rapid early growth. Conversely, large yolk sacs (and embryos) might be at a disadvantage in warm waters with less dissolved oxygen. Fish occupying habitats with a scarcity of food for young would benefit from larger eggs. Individuals from larger yolked eggs would have increased chances of survival. Conversely, fish occupying habitats with high mortality due to predation tend to have many small eggs. There would more likely be adequate food and increased numbers of offspring would raise survival possibilities. Other factors including variations in rate of egg predation with egg size, loss of individual sites for egg deposition as egg size increases and covering all available deposition sites as egg number increases, and decreases in egg number as parental care increases, all might influence the number of eggs produced by a female at one time.

Acknowledgments

This project has been supported by the National Science Foundation and The University of Texas Research Institute. Dr. R. R. Miller aided in collecting Michigan stocks. Drs. A. P. Blair, G. A. Moore, C. D. Riggs, and Mr. John Tilton aided in Arkansas collections. I wish to thank the many other individuals who have assisted me in collecting Texas stocks.

Literature Cited

Fahy, William E. 1954. The life history of the northern greenside darter, *Etheostoma blennioides blennioides* Rafinesque. *Jour. Elisha Mitchell Sci. Soc., 70: 139–205.*

Gordon, Hugh, and Myron Gordon. 1954. Biometry of seven natural populations of the platyfish, *Xiphophorus maculatus*, from Central America. *Zoologica, N. Y. 39: 37–59.*

Hart, J. S. 1952. Geographic variations of some physiological and morphological characters in certain fresh-water fish. *Univ. Toronto Biol. Ser., 60: i–iv, 1–79.*

Holloway, Ancil D. 1954. Notes on the life history and management of the shortnose and longnose gars in Florida waters. *Jour. Wildlife Man., 18: 438–49.*

Hubbs, Clark, and Kirk Strawn. 1956. Interfertility between two sympatric fishes, *Notropis lutrensis* and *Notropis venustus*. *Evolution, 10: 341–44.*

———. 1957a. Survival of F_1 hybrids between fishes of the subfamily Etheostominae. *Jour. Exp. Zool., 134: 33–62.*

———. 1957b. The effects of light and temperature on the reproductive rate of the greenthroat darter, *Etheostoma lepidum* (Girard). *Ecology 38: 596–602.*

Katz, Max. 1948. The fecundity of herring from various parts of the North Pacific. *Trans. Amer. Fish. Soc., 75 (1945): 72–76.*

Lack, David. 1954. The natural regulation of animal numbers. *The Clarendon Press, London: i–viii + 1–343.*

Määr, Alexander. 1949. Fertility of char (Salmo alpinus L.) in the Faxälven water system, Sweden. *Rept. Inst. Freshwater Res. Drottningholm, 29: 57–70.*

Moore, John A. 1942. The role of temperature in speciation of frogs. *Biol. Symposia, 6: 189–213.*

———. 1949. Geographic variation of adaptive characters in *Rana pipiens* Schreber. *Evolution, 3: 1–24.*

Raney, E. C., and E. A. Lachner. 1939. Observations on the life history of the spotted darter, *Poecilichthys maculatus* (Kirkland). *Copeia, 1939: 157–165.*

Shapovalov, Leo, and Allan C. Taft. 1954. The life histories of the steelhead rainbow trout (*Salmo gairdneri gairdneri*) and silver salmon (*Oncorhynchus kisutch*) with special reference to Waddell Creek, California, and recommendations regarding their management. *Calif. Fish. Bull., 98: 1–375.*

Simpson, A. C. 1951. The fecundity of the plaice. *Fish. Invest. Great Britain, Ser. II, 17: 1–27.*

Strawn, Kirk, and Clark Hubbs. 1956. Observations on stripping small fishes for experimental purposes. Copeia, *1956: 114–116.*

Svärdson, G. 1949. Natural selection and egg

number in fish. *Rept. Inst. Freshwater Res. Drottningholm, 29: 115–122.*

VLADYKOV, VADIM D. 1956. Fecundity of wild speckled trout (*Salvelinus fontinalis*) in Quebec lakes. *Jour. Fish. Res. Bd. Canada, 13: 799–841.*

DEPARTMENT OF ZOOLOGY, THE UNIVERSITY OF TEXAS, AUSTIN, TEXAS

Cytological and Histological Studies on the Hybrid of *Platichthys stellatus* × *Parophrys vetulus*, with Notes on its Backcross to *P. vetulus*[1]

WILLIAM ARON

INOPSETTA ISCHYRA was first described as a distinct species, *Parophrys ischyrus*, by Jordan and Gilbert (1880) on the basis of four specimens. The species was redescribed by Villadolid (1927), but no indication of its possible hybrid nature was given. The first published hint of the species' hybrid origin was given by Norman (1934) who stated that *Inopsetta* may prove to be a hybrid between *Lepidopsetta bilineata* and *Platichthys stellatus*. Schultz and DeLacy (1936) concurred with this opinion, but later meristic and morphometric studies by Schultz and Smith (1936) indicated that *Parophrys vetulus* and not *Lepidopsetta* was one of the parents. No further work as regards the hybrid status of *Inopsetta* has been found, although Herald (1941) in reporting the fish from California, and Hubbs and Kuronuma (1942) in their discussion of flatfish hybrids, all seem to agree with the analysis by Schultz and Smith that *Inopsetta* is a hybrid between *Parophrys* and *Platichthys*. None of the above mentioned researches includes any discussion of gonadal development, either anatomic or cytohistologic.

With infrequent exceptions animals found to be hybrids are sterile or partially fertile. The laboratory proof of fertility is usually difficult, so it is remarkable that few investigations have been undertaken to study the gonadal development of suspected hybrids. Kerkis (1933), for example, in his study of an intrageneric hybrid of *Drosphila*, found small gonads with gametogenesis being halted before meiosis could take place. Hubbs (1955) mentions grossly abnormal sperm in hybrid sunfishes. The bulk of the studies of hybrid fish, however, fail to describe even the gross anatomy of the testes or ovaries.

In this study the gonads and the gonadal products of *Inopsetta* are compared to the gonads and gonadal products of *Parophrys* and *Platichthys*, the supposed parents. The wide variability and extensive abnormalities encountered in *Inopsetta* point strongly to its hybrid nature.

MATERIALS AND METHODS

The 29 mature specimens used in this study were taken in Puget Sound during otter trawling operations conducted by the University of Washington School of Fisheries. The fish were taken by the research vessels M.V. COMMANDO and M.V. ONCORHYNCHUS between November 1955 and March 1956. There were 5 male and 7 female *Parophrys*; 3 male and 6 female *Platichthys*; and 2 male, 4 female and 2 hermaphroditic *Inopsetta*.

The *Inopsetta* used in this study were compared with the descriptions given by Jordan and Evermann (1898); with specimens from the collection of the School of Fisheries, University of Washington; and also with meristic counts given by Schultz and Smith (Table I).

Spermatozoan smears were made from milt stripped from ripe fish. The smears were air dried, fixed in methyl alcohol, stained with Giemsa's and mounted in Canada balsam.

Testes and ovaries were removed from the living fish, cut into pieces 5 to 10 mm. in length, and immediately placed in Bouin's fixative. In an effort to reduce the brittleness of heavy yolk deposition some ovaries were fixed in picrosulfuric and Smith's fixatives. After washing, the tissues were dehydrated, cleared in benzol and imbedded in Fisher's "Tissuemat", M.P. 56–58°C. Serial sections were cut at 6–10 microns, stained in Heidenhain's iron hematoxylin or Heidenhain's modification of Mallory's triple stain, and mounted in Canada balsam.

[1] Contribution No. 28 of the School of Fisheries, University of Washington

TABLE I

COMPARISON OF HYBRIDS USED IN THIS STUDY WITH SPECIMENS OF *Inopsetta* DESCRIBED BY SCHULTZ AND SMITH*

	Schultz and Smith	This study
Length in mm......	—	280–400 (7)
Dorsal rays.........	68–77 (14)	68–74 (7)
Anal rays..........	50–57 (14)	50–56 (7)
Pectoral rays.......	11–13 (14)	11–13 (7)
Gillrakers below angle	9–10 (12)	9–10 (7)

* Numbers in parentheses indicate number of specimens studied.

DESCRIPTION

Table II summarizes the results of the examination of 100 spermatozoa from *Inopsetta.* The size frequency distribution of their heads and the size limits for sperm heads of *Platichthys* (56 measurements from 3 specimens) and *Parophrys* (54 measurements from 4 specimens) are given in Figure 1. These data were obtained by studying all sperm encountered in randomly selected microscope fields.

The spermatozoa of *Parophrys* and *Platichthys* are morphologically indistinguishable. They closely resemble those of the silver salmon, *Oncorhynchus kisutch,* as described by Lowman (1953). The head is ovate to spherical with the acute end directed anteriorly. The long axis measures from 1.8 to 2.1 μ and the maximum width varies from 1.6 to 1.8 μ. Light microscope studies fail to reveal the presence of a neck-piece, but according to Lowman (personal communication) the neck-piece of the salmon spermatozoan also cannot be seen with the light microscope. Length of tail, based on 30 measurements of *Parophrys,* ranges from 35.0 to 50.0 μ.

The hybrid's spermatozoa are best characterized by their variability, with 70 per-

TABLE II

SUMMARY OF THE EXAMINATION OF 100 SPERMATOZOA FROM THE HYBRID FISH

Normal	Abnormal*						
	H	N	T	H + N	H + T	N + T	H + N + T
30	24	13	8	10	7	4	4

* H = head abnormal; N = neck-piece present; T = tail thickened or with multiple flagella.

cent showing some morphological abnormality. The heads are extremely irregular, but generally are globular to tear-drop in shape. Measurements along the long axis of 100 spermatozoan heads from two specimens varied from 0.5 to 7.5 μ and averaged 4.0 μ. The neck-piece was usually not visible, but in some spermatozoa what probably is the neckpiece appeared as a pinched-off portion of the head. Most of the hybrid's spermatozoa lacked tails; some had short, thick tails; some had tails which were apparently normal; and others had multiple tails, some with as many as seven filaments. Figures 2a and 2b clearly show the wide differences in appearance between the spermatozoa of *Parophrys* and *Inopsetta.*

Testes.—Comparisons between the testes of the hybrid fish and its alleged parents re-

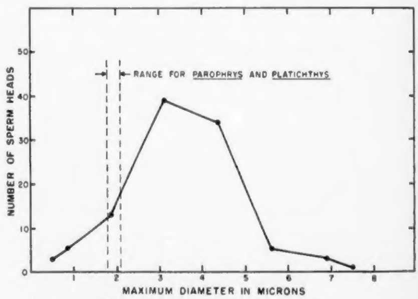

FIG. 1. Size frequency of *Inopsetta* sperm heads.

veal several sharp differences. The sections through the testes of the parent species are normal in appearance (Fig. 2c). In *Parophrys,* spermatogonia, secondary spermatocytes, spermatids, and spermatozoa are clearly defined and are consistent in size and shape. Because cell boundaries were poorly differentiated, the maximum diameter of the nucleus was used as an index of cell size. The nucleus of spermatogonial cells was approximately 6.0 μ in diameter, its nucleolus measuring 1.7 μ in diameter. Secondary spermatocytes had a nucleus 3.3 μ across, and the nucleus of the spermatids measured 1.5 μ in diameter. Regular areas of actively dividing, normal appearing cells are seen, and no indications of anaphase sticking or other disruptions of the spermatogenic process can be noted. In both parent species multinucleated spermatogonial cells are found, but never in great abundance.

Sections of the testes of the hybrids, on the

other hand, are abnormal in appearance (Fig. 2d). Both male hybrids examined were ripe but spermatocytes, and probably spermatids, were present as well as spermatogonia and spermatozoa. The spermatocytes and spermatids were not confined to regular, clearly defined areas as in *Parophrys*, but were scattered amid masses of mature spermatozoa. The extreme variability in size and shape of these cells, their nuclei ranging in diameter from less than 1.0 μ to about 7.0 μ, made it impossible to distinguish between spermatocytes and spermatids. However, spermatogonial cells were consistent in appearance, their nuclei measuring about 7.5 μ in diameter, their nucleoli being 1.7 μ across. In all sections made through the testes of the hybrid, multinucleated spermatogonial cells were common.

Ovaries.—Sections through the ovaries of *Parophrys* and *Platichthys* closely resemble one another (Fig. 3a). All sections examined were tightly packed with developing oocytes. Sections through the ovary of ripe females showed that nearly all eggs were mature, with only a scattering of undeveloped oocytes. Few oogonial cells can be found and these are imbedded in the ovarian wall and in the septa which divide the lumen of the ovary. The nuclei of the oogonial cells range from about 5.0 μ to 8.0 μ in maximum diameter. In nearly all oocytes the nucleus is centrally located. Examination of all sections failed to reveal the presence of multinucleated oocytes.

Ovarian sections of three of the hybrids used in the study reveal great variations between fish. The sections from the 298 mm. female are so different from those from the 280 mm. and 400 mm. fish that it is difficult to reconcile the fact that these sections are from the same species or hybrid combinations (Figs. 3b, 3c, 3d). Sections from the 298 mm. fish resemble those from the parent species in general appearance, except for the abundance of abnormal cells which appear in the interstitial tissue between the oocytes. These cells appear to be either aborted oogonia, or oocytes, or both. No multinucleated oocytes are to be found and all oocytes are in about the same stage of development. The nucleus in nearly all of the oocytes of this fish is at one side of the cell, and the yolk material stained with great intensity.

Sections through the ovaries of the 280 mm.

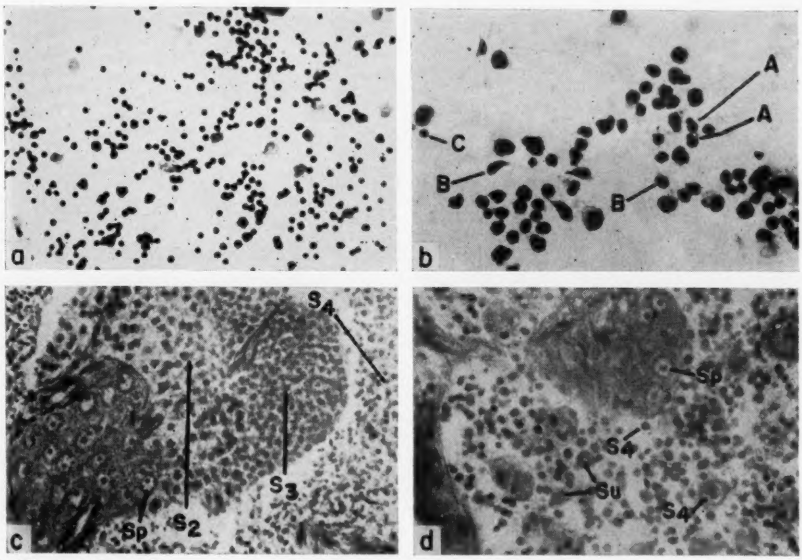

Fig. 2. a. *Parophrys vetulus* sperm smear. b. Hybrid sperm smear. Sperm with neckpiece (A), sperm showing abnormal tail (B), normal shaped sperm head (C). c. *Parophrys vetulus*, cross section through the testes. Spermatogonial cells (Sp), secondary spermatocytes (S_2), spermatids (S_3), spermatozoa (S_4). d. Hybrid, cross section through the testes. Unidentified spermatogenic cells (Su).

and 400 mm. females are essentially alike except for the greater maturity of the larger fish. The timing of oocyte development in these fish is erratic, with oocytes almost 0.4 mm. in diameter being found alongside much smaller cells which have just begun yolk deposition. In both fish the number of developing oocytes is far less than in either the 298 mm. hybrid or the parent species. The oocytes themselves are nearly normal in appearance, except for the eccentric position of the nucleus in many cells and the occurrence of occasional multinucleated oocytes (Fig. 3d). Extensive areas of oogonial cells fill the bulk of the ovary, particularly in the 280 mm. specimen. The size of the nucleus in the oogonial cells shows great variation with maximum diameters ranging from about 2.7 μ to 14.0 μ. Meiotic cells occur in small patches throughout the ovaries and are generally characterized by a heavy clumping of their chromosome complement. Some evidence of anaphase sticking is also seen in the dividing cells.

Hermaphroditic Gonads.—Two of the hybrid fish studied were hermaphrodites. The 291 mm. specimen was immature and prior to microscopic investigation was described as a male. The 367 mm. fish was considerably further along in its gonadal development, having patches of fully developed spermatozoa present throughout the ovotestes. Prior to microscopic investigation this fish had been described as a female. The differences between the two fish are such that they will be described separately.

Sections through the gonad of the 291 mm. hybrid reveal a large mass of extremely variable gonia (Figs. 4a, 4b, 4c). The maximum diameter of the nuclei of these cells ranged from 2.7 μ to 14.0 μ. The nucleoli varied in diameter from about 0.6 μ to 7.0 μ. The size of the nucleolus, however, was not well correlated with nuclear size, as large nuclei frequently had small nucleoli and vice versa. Multinucleated gonial cells are common, some cells having as many as 8 nuclei. Scattered among the spermatogonial cells are fairly large cells, the nuclei of which vary from 7.5 μ to 10.0 μ in maximum diameter but lacking the nucleolus present in the spermatogonia. These are probably the primary spermatocytes. Patches of cells, probably secondary spermatocytes, with nuclei having a maximum diameter of about 4.4 μ are spread through the gonad. Smaller patches of cells, having nuclei with a maximum diameter of about 2.3 μ, are also found

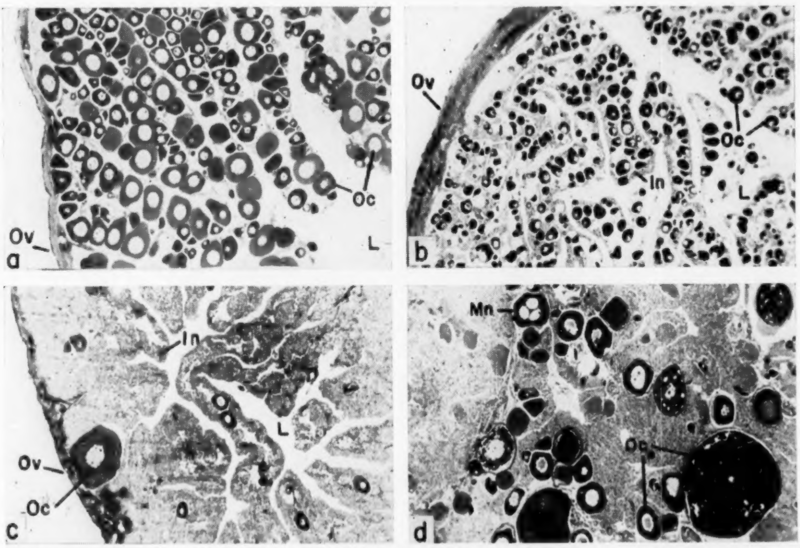

Fig. 3. a. *Platichthys stellatus*, cross section through the ovary. Ovarian wall (Ov), lumen of ovary (L), oocyte (Oc). b. 298 mm. hybrid, cross section through the ovary. Interstitial tissue (In). c. 280 mm. hybrid, cross section through the ovary. d. 400 mm. hybrid, cross section through the ovary. Multinucleated oocyte (Mn).

These are probably spermatids. Also present are cells which are apparently developing oocytes. In these the deposition of yolk material is not well advanced and the largest measured only 22.0 μ in maximum diameter.

The 367 mm. specimen, because of its greater maturity, presents a slightly more complex picture (Fig. 4d). All stages of spermatogenesis are present, as are developing oocytes ranging from those which have just begun yolk deposition to some almost 0.4 mm. in diameter. The gonial cells in this ripe males. The developing oocytes occupy less than 20 per cent of the ovo-testes. Except for the great variation in development between cells, they generally have a normal appearance. No multinucleated oocytes were found.

Backcross.—On March 13, 1956 one ripe female *Inopsetta* was found. The fish was kept alive in the aquarium until March 16, when approximately 2000 eggs were stripped and fertilized with milt from a *Parophrys*.

No accurate estimate of mortality was

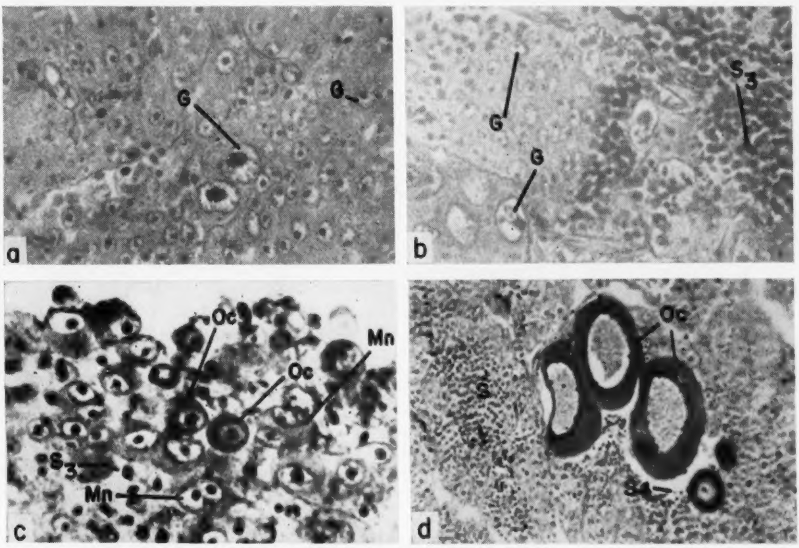

Fig. 4. a. 291 mm. hermaphroditic hybrid, cross section through the ovo-testes. Gonial cells (G). b. 291 mm. hermaphroditic hybrid, cross section through the ovo-testes. Spermatids (S_3). c. 291 mm. hermaphroditic hybrid, cross section through the ovo-testes. Oocyte (Oc), multinucleated gonial cells (Mn). d. 367 mm. hermaphroditic hybrid, cross section through the ovo-testes. Area of spermatogenesis (S), spermatozoa (S_4).

specimen are normal in appearance, their nuclei having a maximum diameter of about 6.7 μ and their nucleoli measuring about 1.7 μ across. The nuclei of the primary spermatocytes have a maximum diameter of 10.0 μ; the nuclei of the secondary spermatocytes measure 3.8 μ across; the spermatid nucleus is about 2.3 μ in its maximum diameter. The chromosomes during the maturation divisions, particularly in the second maturation division, tend to clump together, and there appears to be an uneven distribution of chromatin material between cells. This uneven distribution is probably reflected in the varying size and shape of the spermatozoa, which are similar to those described in the made for the developing eggs of the backcross, but the mortality was great, certainly in excess of 50 percent for the first 12 hours after fertilization. Early cell divisions were not observed; however, after 8 hours the blastodermal cap had already formed (Budd, 1940, pls. I and II). By 31 hours eggs had reached the early germ ring stage, and by 36 hours the embryonic shield had begun formation. Up to this point the timing of development was fairly constant, that is, all eggs that were developing reached the same stage at about the same time. By 60 hours the closure of the blastopore had occurred in some eggs, but this stage was not reached by many eggs until 72 hours had

passed. Many abnormal eggs were observed. Some contained double embryos; others had embryos showing spinal curvature; and still others showed incomplete development, the anterior end of the embryo being fairly normal, but the posterior half being either distorted or actually missing. The eggs began hatching by 114 hours, and after 132 hours no new larvae were observed. Of the approximately 2000 eggs which were fertilized only about 200 survived to hatch. Newly hatched larvae, measured after preservation for 5 months in 5 percent formalin, ranged in total length from 1.89 mm. to 2.11 mm. Two larvae survived for 3 days. Their total lengths, also measured after 5 months preservation in 5 percent formalin, were 2.89 and 3.11 mm.

Comparison of the newly hatched and normal appearing larvae with those described by Budd for *Parophrys* reveals a close resemblance. The backcross larvae are characterized, in nearly all cases, by the presence of an area of pale amber color bordering the posterior margin of the eye, and an amber band encircling the tail about half way between the anus and the tip of the tail. There is no pigmentation on the fin folds or the yolk sac. Examination of the larvae by Mr. Thomas S. English, School of Fisheries, University of Washington, and by Mr. Cleveland P. Hickman, Jr., University of British Columbia, both of whom have worked extensively with flatfish larvae, confirmed the resemblance to *Parophrys*. About one-half of the hatch was obviously abnormal, consisting of larvae with spinal curvature, abnormally large heads, and/or shrunken tails.

Discussion

The data demonstrate that there are far greater variations between the different specimens of the hybrid fish than there are between the alleged parent species. The actual mechanism responsible for these variations is uncertain; however, the abnormalities encountered, i.e., hermaphroditism, clumping of chromosomes, abnormal germ cells, are typical of many reported hybrids (White, 1948). It is difficult to conceive of a true species exhibiting the profoundly abnormal gametogenic processes found in *Inopsetta*. The evidences remove nearly all doubt of the hybrid nature of *Inopsetta*.

Although cytological evidence points to the hybrid nature of *Inopsetta*, it in no way indicates the parent species. *Parophrys* and *Platichthys* were used for comparative purposes simply because other workers have suggested them as the progenitors. Histological technique is of little use in determining parental species. Negative results, i.e., the finding of normal gametogenesis, do not necessarily prove that the specimen is a true species. Extensive gametogenic anomalies in a suspected hybrid, however, would certainly strengthen the case for the hybrid origin of the specimen. Also, it must be pointed out that gametogenesis in hybrids may be perfectly normal or only slightly abnormal. One of the best examples of this is in the hybrid cross between *Zea mays* and *Euchlaena mexicana* (Sharp, 1943). The offspring are fertile, synapsis tends to be regular, and even crossing over takes place. There are also reported fertile fish hybrids (Gordon, 1947; Foerster, 1935). Gametogenesis has not been studied in these fish, but it is possible that no abnormalities occur.

The backcross between the female hybrid and the male *Parophrys* yielded only speculative results. The high egg mortality cannot be attributed definitely to the nature of the female used in the cross since the fertility of the male is open to doubt. Lack of availability of other material prevented control matings from being carried out. Also, the great numbers of abnormal embryos and larvae which resulted cannot be attributed definitely to the nature of the cross. Abnormalities, such as those which have been described, occur with fair frequency in normal matings. It is possible that culture conditions rather than heredity are responsible for the aberrant development. For example, abnormalities similar to those reported here also are reported by both Donaldson (1955) and Seymour (1956) in chinook salmon (*Oncorhynchus tshawtscha*) where the matings were between normal fish. In these reports the number of abnormalities was greatest in the experimental groups raised at the temperature extremes for the species. What is most interesting in the flatfish cross is the similarity between the hatched larvae and the larvae of *Parophrys*. Theoretically this similarity may be explained as follows. The female hybrid has a chromosome constitution which is the sum of the haploid sets of the presumed progenitors, *Parophrys* and *Platichthys*. At meiosis in the female a random assortment of chromosomes takes place and it is possible that some eggs will come to possess mostly *Parophrys* or *Platichthys* chromosomes. The chances of this happening are, of course, directly dependent upon the number of chromosomes. The greater the number

and the higher the frequency of crossing over, the lower the chances of producing an egg bearing a great majority of chromosomes of a single species. In this species, where egg production is enormous, fair numbers of such eggs may be produced in spite of the high chromosome number which characterizes most vertebrates. At fertilization those eggs with the chromosome complement most similar to the complement of the sperm are most likely to develop successfully.

With the purpose of developing new stocks of fish, many hybridization experiments have been carried out, particularly with salmonid fishes. All possible crosses of the five species of *Oncorhynchus* occurring in British Columbia were made by Foerster (1935) with some degree of success. Other crosses of salmonids, some inter-generic, are discussed in detail by Svardson (1945), Alm (1954), and Buss and Wright (1956). These latter works point out that the greatest success occurs when the crosses are made between species having the most similar chromosomes. If one considers that the chromosomic differences between species of *Oncorhynchus* are probably less than those differences between *Platichthys* and *Parophrys*, it is not surprising that the abnormalities reported in this paper do occur.

Acknowledgments

The writer wishes to express his appreciation to Dr. James E. Lynch for his guidance during the course of the investigations and to other members of the faculty of the School of Fisheries, University of Washington for their aid and suggestions. The author is also grateful to the following people, all from the University of Washington: Dr. Frank G. Lowman, who contributed many important suggestions and gave unsparingly of his time and knowledge; Dr. Edward C. Roosen-Runge for his help in interpreting sections of testes material; Mr. Sayed el Sayed and Mr. Kenneth Vaughan for their assistance in collecting fish; and Mrs. Edith Haselwood, Miss Helen Haukeness, Mr. Harold Babcock, and Mr. Donald Doyle for their editorial assistance.

Literature Cited

Alm, G. 1954. Artificial hybridization between different species of the salmon family. *Institute of Freshwater Research, Drottningholm, Report No. 36: 13–56.*

Budd, P. L. 1940. Development of the eggs and early larvae of six California fishes. *Calif. Div. Fish and Game, Fish. Bull., 56: 1–53.*

Buss, K. and J. E. Wright. 1956. Results of species hybridization within the family Salmonidae. *Progressive Fish Culturist, 18(4): 149–58.*

Donaldson, J. R. 1955. Experimental studies on the survival of the early stages of chinook salmon after carrying exposures to upper lethal temperatures. *Master's Thesis, University of Washington 116. pp.*

Foerster, R. E. 1935. Inter-specific cross breeding of Pacific salmon. *Trans. Royal Soc. Canada, Third Series, 29(5): 21–33.*

Gordon, M. 1947. Speciation in fishes; distribution in time and space of seven dominant multiple alleles in *Platypoecilus maculatus. Advances in Genetics, 1: 95–132.*

Herald, E. S. 1941. First record of the hybrid flounder, *Inopsetta ischyra,* from California. *California Fish and Game, 27(1): 44–6.*

Hubbs, C. L. 1955. Hybridization between fish species in nature. *Syst. Zool. 4(1): 1–20.*

Hubbs, C. L. and K. Kuronuma. 1942. Analysis of hybridization in nature between two species of Japanese flounders. *Papers Mich. Acad. Sci., Arts and Letters, 27 (1941): 267–306.*

Jordon, D. S. and B. W. Evermann. 1898. The fishes of north and middle America. *Bull. U. S. Nat. Mus. 47 (3): 2183–3126.*

Jordan, D. S. and C. S. Gilbert. 1880. Description of two new species of flounders (*Parophrys ischyrus* and *Hippoglosoides elassodon)* from Puget's Sound. *Proc. U. S. Nat. Mus., 3: 276–80.*

Kerkis, J. J. 1933. Development of gonads in hybrids between *Drosophila melanogaster* and *Drosophila simulans. Jour. Exp. Zool., 66 (3): 477–509.*

Lowman, F. G. 1953. Electron microscope studies of silver salmon spermatozoa (*Oncorhynchus kisutch* (Walbaum)). *Exp. Cell Research, 5 (2): 335–60.*

Norman, J. R. 1934. A Systematic Monograph of the Flatfishes (Heterosomata). Volume I. Psettodidae, Bothidae, Pleuronectidae. *British Museum, London. 459 pp.*

Schultz, L. P. and A. C. DeLacy. 1936. Fishes of the American Northwest. A catalogue of the fishes of Washington and Oregon with distributional records and a bibliography. *Jour. Pan-Pac. Res. Inst., in Mid-Pac. Mag., 49 (1): 63–68.*

Schultz, L. P. and R. T. Smith. 1936. Is *Inopsetta ischyra* (Jordan and Gilbert), from Puget Sound, Washington, a hybrid flatfish? Copeia *1936 (4): 199–203.*

Seymour, A. H. 1956. Effects of temperature upon young chinook salmon. *Doctor's Thesis, University of Washington. 127 pp.*

Sharp, L. W. 1943. Fundamentals of Cytology. *New York, McGraw-Hill Book Co., Inc., 270 pp.*

Svardson, G. 1945. Chromosome studies on Salmonidae. *Reports from the Swedish State Institute of Fresh-water Fishery Research, Drottningholm, 1–151.*

Villadolid, D. V. 1927. The rediscovery of *Inopsetta ischyra*, a rare species of flounder. *Ann. Carn. Mus., 17: 395–97.*

White, M. J. D. 1948. Animal Cytology and Evolution. *Cambridge at the University Press. 375 pp.*

A Comparative Study of the Postlarvae of Three Flounders (*Paralichthys*) in North Carolina

Earl E. Deubler, Jr.

THE most comprehensive study on the biology of *Paralichthys* is that of Hildebrand and Cable (1930: 464–476) conducted at Beaufort, North Carolina; they recognized two species but were unable to distinguish between the postlarvae. Ginsburg (1952: 319), who clearly defined three species (*dentatus, lethostigma,* and *albigutta*) from the Beaufort area, stated, "Since, however, three closely related species of *Paralichthys* are common there, and it is difficult or impossible to separate the fry by species, Beaufort is not a favorable place to study the development of *dentatus.*" Considering the difficulty that investigators experienced in determining the validity of the three species when using adult specimens, it is not surprising that Hildebrand and Cable found it necessary to base their postlarval descriptions of *Paralichthys* on a composite, apparently of three species.

This paper includes data which make it possible to distinguish the late postlarval forms of *P. dentatus, lethostigma,* and *albigutta.* Thus, future investigations into early aspects of the life histories of these species are facilitated.

Materials and Methods

Many postlarvae of *Paralichthys* were collected from eastern Bogue Sound at Beaufort and Morehead City, North Carolina, and from northern Pamlico Sound at Oregon Inlet, North Carolina, during the periods December, 1955 to April, 1956 and December, 1956 to April, 1957. These are housed in the Fish Research Collection of the University of North Carolina at Morehead City, North Carolina, and are listed by catalogue number (UNC). *Paralichthys dentatus:* 960, 970, 984, 988, 991, 998, 808, 131, 9, 29, 20, 169. *Paralichthys lethostigma:* 34, 170, 168, 10, 8, 23, 971, 976, 979, 981, 986, 989, 992, 995, 1000, 1002, 961, 956. *Paralichthys albigutta:* 959, 962, 945, 963, 936, 965, 898, 969, 972, 974, 975, 978, 982, 985, 990, 996, 999, 1003.

The term postlarvae as used in this paper includes individuals that have completely absorbed the yolk sac but have not developed the definitive characters of the species (Hubbs, 1943: 260).

Collecting for postlarvae was confined to protected inside waters because of the lack of facilities for offshore work. Three sizes of conically-shaped nets with nylon webbing were used at various times. These had the following specifications in mouth diameter and mesh: (1) 76 cm.; 1 mm.; (2) 100 cm.; 1 mm.; (3) 152 cm.; 1.5 mm. No attempt was made to test the fishing efficiency of these nets; however, it was apparent that the largest net collected the most fish.

The postlarvae were collected by sampling from bridges, boat docks, and boats. In all sampling areas the tidal current was sufficiently strong to hold the net at the surface of the water. On several occasions fishing was done during both daylight and night hours, on comparable stages of the tide, to determine whether a difference occurred in the number of postlarvae captured between day and night sets. Normally, collecting was done after dark.

Examination of the postlarvae of *Paralichthys* showed that they could be separated into two distinct groups (originally designated types A and B) by using apparent differences in pigmentary pattern. To determine whether these pigmentary differences could be used to differentiate among species, approximately 100 individuals of each group were placed in aquaria on 22 February 1956 and an attempt was made to raise these to a determinable size. The postlarvae were initially fed on brine shrimp (*Artemia*), and, when larger, were fed cut shrimp (*Penaeus*). An early and high rate of mortality prohibited the subsampling of these groups at intervals during their development.

Attempts to obtain live postlarvae from Bogue Sound during the period December 1956 to April 1957 failed to yield sufficient numbers of either pigmentary group for rearing. However, approximately 400 postlarvae of type B were collected at Oregon Inlet, North Carolina on 9 January 1957. These were successfully returned to the laboratory and the majority were raised to a definitive size in aquaria. These were fed brine shrimp (*Artemia*), white worms (*Enchytraeus*), and cut shrimp (*Penaeus*).

A subsample of 20 individuals (type B) was killed and preserved in 10 percent formalin at weekly intervals, 23 January through 9 March 1957. The experiment was terminated on 16 April 1957. Five individuals from each subsample were macerated in a two percent solution of potassium hydroxide, stained with alizarin red S, and cleared in glycerin (Evans, 1948: 42–47) for the purpose of studying gillraker development. The standard length of each specimen was recorded to the nearest 0.5 mm. using dividers and a steel rule marked in 0.5 mm. units.

In addition to retaining postlarvae alive, specimens of types A and B were fixed in 10 percent formalin immediately upon capture and stored in 40 percent isopropyl alcohol. Meristic characters were examined using those which Ginsburg (1952: 269–275) found of value in delineating fully-formed members of the species. These included dorsal rays, anal rays, and gillrakers. Vertebrae were also counted. Standard length was taken to the nearest 0.1 mm. using a binocular microscope equipped with an ocular micrometer.

Morphometric characters were avoided in this study because of the considerable heterogony which occurs over a small size range during postlarval development. It would be difficult to determine whether morphometric

Table I

Standard Length and Meristic Data for Postlarvae of *Paralichthys dentatus, lethostigma,* and *albigutta* Collected in North Carolina During the Periods December, 1955 to April, 1956 and December, 1956 to April, 1957

Species	Standard Length Taken to the Nearest Millimeter											
	7	8	9	10	11	12	13	14	15	16	N	M
dentatus	—	—	2	6	15	25	18	18	5	—	89	12.4
lethostigma	—	4	39	105	59	8	—	1	—	1	217	10.2
albigutta	5	35	30	1	—	—	—	—	—	—	71	8.4

Dorsal Rays

	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	N	M
dentatus	—	—	—	—	—	—	—	—	—	1	2	—	2	5	8	8	9	8	15	14	9	2	4	87	89.0
lethostigma	—	—	—	—	—	—	2	1	3	6	11	15	25	27	38	24	25	19	28	12	14	3	2	255	86.7
albigutta	2	1	3	4	9	6	10	3	6	3	2	—	—	—	—	—	—	—	—	—	—	—	—	49	77.3

Anal Rays

	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	N	M
dentatus	—	—	—	—	—	—	—	—	1	—	2	6	2	8	9	14	15	10	8	4	3	2	84	68.4
lethostigma	—	—	—	—	—	—	—	—	—	—	4	18	19	39	61	39	36	28	26	8	1	2	281	67.8
albigutta	1	3	3	6	10	7	16	5	10	3	1	—	—	—	—	—	—	—	—	—	—	—	65	58.4

	Thoracic Vertebrae						Caudal Vertebrae							
	9	10	11	12	N	M	26	27	28	29	30	31	N	M
dentatus	—	1	46	1	48	11.0	—	—	—	1	32	15	48	30.3
lethostigma	1	37	1	—	39	10.0	1	34	3	1	—	—	39	27.1
albigutta	1	24	—	—	25	10.0	1	17	7	—	—	—	25	27.2

	Total Vertebrae									Gill Rakers on Outer Arch															
	36	37	38	39	40	41	42	N	M	0	1	2	3	4	5	6	7	8	9	10	11	12	13	N	M
dentatus	—	—	—	—	1	32	15	48	41.3	6	—	1	—	2	—	2	2	3	2	1	1	1	1	22	5.6
lethostigma	—	35	4	—	—	—	—	39	37.1	—	—	—	—	2	4	11	7	4	—	—	—	—	—	28	6.2
albigutta	1	18	6	—	—	—	—	25	37.2	8	2	—	3	1	1	1	—	—	—	—	—	—	—	16	1.6

differences among the species were real, or merely due to size differences at the time of capture. The standard lengths and meristic data of the postlarvae have been compiled in the form of frequency distributions in Table I.

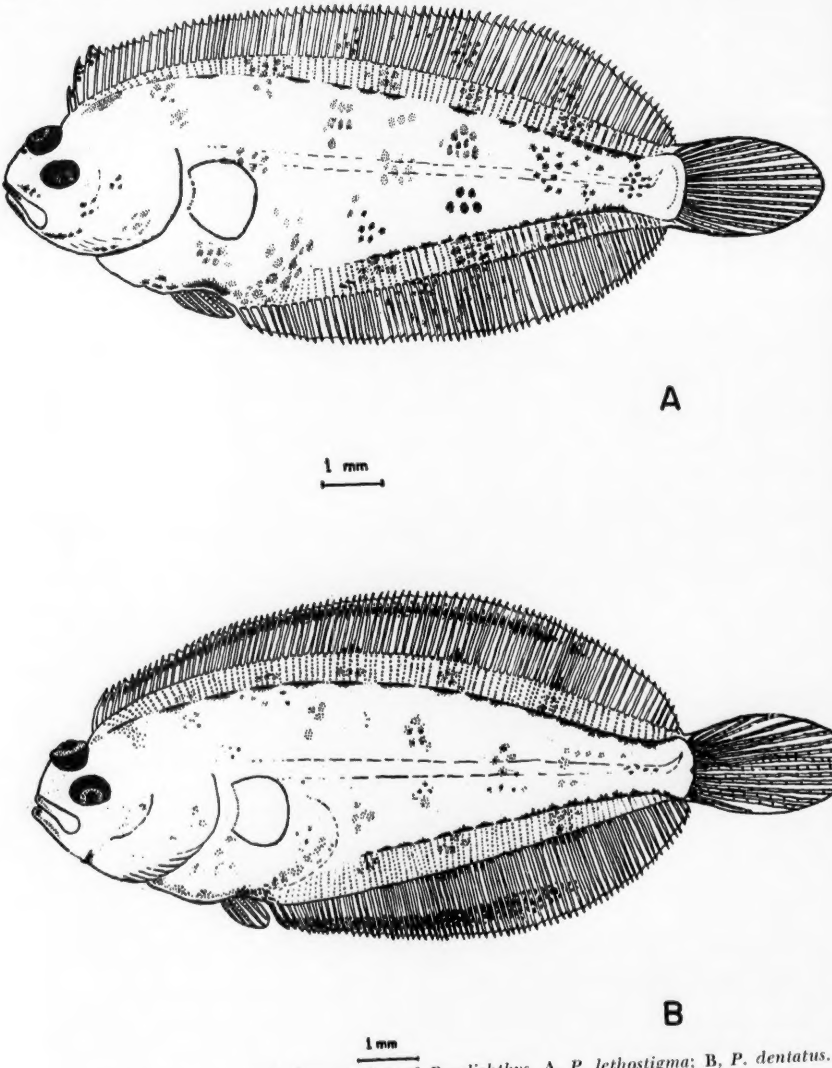

Fig. 1. Late postlarval pigmentation of *Paralichthys*. A, *P. lethostigma*; B, *P. dentatus*.

Discussion

The smallest *Paralichthys* postlarvae collected in this study were 7 mm. in standard length (Table I). Hildebrand and Cable (1930: 470) collected postlarvae as small as 2.5 mm. in total length. However, such extremely small sizes were captured by them only at sea. The larger sizes found by them were collected both at sea and in protected waters of Bogue Sound and the Newport and North rivers. They concluded that the absence of small sizes in inside waters of the sounds indicates that *Paralichthys* most

probably spawns at sea. The failure to collect early postlarval stages in inside waters in this study corroborates that conclusion.

Hildbrand and Cable (1930: 474) stated that postlarvae exceeding 10 to 12 mm. in total length are rarely taken with a one-meter townet. This is contrary to the findings of the present study, for during the period December 1955 to April 1956, postlarvae (types A and B) 7 to 16 mm. in standard length were among the most common forms taken. However, during the period December 1956 to April 1957, postlarvae were relatively rare as compared with the catches of the 1955–1956 season. The reason for this phenomenon is unknown but may be the reflection of a relatively unsuccessful year-class for the 1956–57 season.

In addition to wide fluctuations in abundance of postlarvae between these two seasons, there was a pronounced difference in the numbers collected during daylight and night hours using the same collecting gear and fishing on comparable stages of the tide. Although postlarvae were collected in abundance during the night hours of the 1955–56 season, very few were collected during the daytime. It may be that the findings of Hildebrand and Cable (1930: 464–476) are based on daylight collections. This would explain, at least in part, why they experienced little success in capturing large postlarvae.

Daytime collections yielded not only fewer flounder postlarvae, but also smaller numbers of postlarvae of *Brevoortia tyrannus, Lagodon rhomboides, Leiostomus xanthurus*, and *Micropogon undulatus* which are common in Bogue Sound during winter and spring months. Bridger (1956: 42–57) discussed variation in catches of clupeid larvae between day and night tows. He found that night tows yielded more larvae than day tows, and also that the increase in catch at night is related to the size of the larvae. He attributed the difference in catches between day and night tows to avoidance of the net by the larvae during daylight hours. It is likely that the increased catches of flounder postlarvae as well as those of other fishes during the night hours, in the present study, are due to better escapement during the daytime. They are indeed strong and active swimmers.

A significant difference exists in the sizes of the postlarvae among the three species of *Paralichthys* captured in the upper strata of the inside waters (Table I). The postlarvae of *dentatus* were significantly larger than those of *lethostigma* or *albigutta*. The postlarvae of *albigutta* are the smallest of the three forms. From this, it appears likely that the postlarvae of the three species found in the upper layers of water seek the bottom at different sizes.

The two pigmentary groups of postlarvae, when raised to a definitive size in aquaria, comprised three species of *Paralichthys*. Those originally designated as type A proved to be a composite of two species, *lethostigma* (one specimen killed at a size of 57 mm., S.L., on 12 December 1956) and *albigutta* (two specimens, 48 and 54 mm., S.L., killed on 12 December 1956). Type B proved to be *Paralichthys dentatus* (one specimen, 41 mm., S.L., killed on 27 August 1956). The identification of type B was further substantiated by the rearing experiment initiated with this group on 9 January 1957. All individuals were *dentatus*.

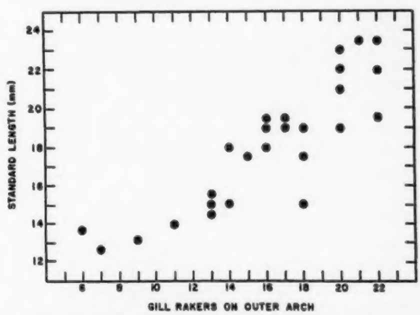

Fig. 2. Relationship of total number of gill-rakers on outer arch to standard length (mm.) in laboratory-reared specimens of *Paralichthys dentatus*.

The postlarvae of *dentatus* (9–15 mm., S.L.) can be separated from the postlarvae of *lethostigma* (8–16 mm., S.L.) and *albigutta* (7–10 mm., S.L.) by the fact that *dentatus* has a well-defined band of black pigment along the border of the anterior four-fifths of the dorsal fin, and of the anterior two-thirds of the anal fin (Fig. 1 B). Postlarvae of *lethostigma* (Fig. 1 A) and *albigutta* lack these pigment bands.

The only additional character found useful in separating the late postlarvae of *dentatus* from *lethostigma* is the number of vertebrae. *P. dentatus* normally has 40 to 42 vertebrae but *lethostigma* has 37 or 38 in the specimens examined (Table I).

Other than pigmentary differences, the postlarvae of *dentatus* can best be separated

from *albigutta* by using vertebral counts (Table I); however, the great majority of specimens can also be identified by using dorsal and anal ray counts (Table I).

The postlarvae of *lethostigma* and *albigutta* are difficult to separate at the sizes studied, for no pigmentary differences have been recognized, and vertebral counts for the two species are the same (Table I). The number of anal rays is the best diagnostic character found but the number of dorsal rays will also separate the majority of specimens (Table I). No single character has been found that will clearly separate all postlarvae of *lethostigma* from those of *albigutta,* and as Ginsburg (1952: 268) found with fully-formed individuals, it has been necessary to use a combination of characters to determine properly the postlarvae in this study.

Ginsburg (1952: 269) found that the most useful differentiating characters among fully-formed individuals of the three species are meristic. He showed that *dentatus* can be distinguished readily from *lethostigma* and *albigutta* by gillraker counts. *P. dentatus* normally has 16 to 24 rakers on the outer gill arch; *lethostigma* has 10 to 13, and *albigutta* has 11 to 15. Unfortunately, gillrakers are not fully formed in any of the species at the sizes examined (Table I), and cannot be used in defining postlarvae. Using laboratory-reared specimens, it appears that the definitive number of gillrakers is present in *dentatus* at a minimum size of 15 mm., S.L., but usually not before a size of 18 mm., S.L. is reached (Fig. 2).

Summary

Postlarvae of *Paralichthys* from North Carolina waters were studied to determine which species are represented.

Collecting success varied markedly between two years, but was invariably better during the night hours of both.

The late postlarvae of *P. dentatus* can best be distinguished from those of *lethostigma* and *albigutta* by using differences in pigmentary pattern. In addition *dentatus* differs from the other two species in vertebral count. *P. dentatus* can also be separated from *albigutta* by anal ray and dorsal ray counts.

Postlarvae of *lethostigma* are difficult to separate from *albigutta*. The only characters found of value were dorsal ray and anal ray counts.

Acknowledgments

The writer thanks Rudolph J. Miller who prepared the illustrations of the postlarvae; Joseph R. Higham, John W. Reintjes, and Charles M. Roithmayr who helped collect specimens; Charles F. Cole and William A. Lund for their help in the laboratory; and Drs. William E. Fahy, Edward C. Raney, and Austin B. Williams for valuable suggestions concerning the manuscript.

Literature Cited

Bridger, J. P. 1956. On day and night variation in catches of fish larvae. *Cons. Perm. Internat. Explor. Mer. Jour. du Cons., 22(1): 42–57.*

Evans, H. E. 1948. Clearing and staining small vertebrates, in toto, for demonstrating ossification. *Turtox News, 26(2): 42–47.*

Ginsburg, Isaac. 1952. Flounders of the genus *Paralichthys* and related genera in American waters. *Fishery Bull. U. S. Fish and Wildlife Service, 52 (Fishery Bull. 71): 267–351.*

Hildebrand, Samuel, F., and Louella E. Cable. 1930. Development and life history of fourteen teleostean fishes at Beaufort, N. C. *Bull. U. S. Bur. Fish., 46(Doc. 1093): 383–488.*

Hubbs, Carl L. 1943. Terminology of early stages of fish. Copeia *(4): 260.*

Institute of Fisheries Research, University of North Carolina, Morehead City, North Carolina.

A New Species of Fish from the Western North Atlantic, *Dikellorhynchus tropidolepis*, and Relationships of the Genera *Dikellorhynchus* and *Malacanthus*

Frederick H. Berry

THREE extraordinary specimens taken from the stomach of a dolphin, *Coryphaena hippurus* Linnaeus, represent a previously undescribed form. The three, 55, 56.5, and 60 mm. in standard length, were identified as *Malacanthus plumieri* (Bloch)

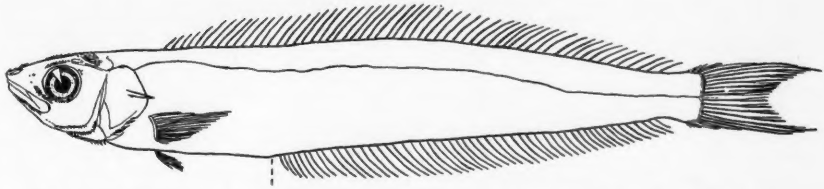

Fig. 1. *Dikellorhynchus tropidolepis,* holotype, 56.5 mm. in standard length, USNM 158376.

(in Anderson, Gehringer, and Cohen, 1956: 54) because of the apparent similarity of major morphological and meristic characters. They were considered worthy of published description and illustration because of the presence of keeled scales and multiple spines and serrations on the head, not present on adult *M. plumieri.* Then my attention was directed to a grossly similar form from South Africa, described as a new genus and species, *Dikellorhynchus incredibilis,* by Smith (1956). Smith's specimen was about 60 mm. in standard length, and, although he judged it to be a new species, he suggested that it might represent a hitherto unknown juvenile stage of *Malacanthus hoedtii* Bleeker of the Indo-pacific. The three specimens were compared with a U. S. National Museum specimen of *M. plumieri,* 55.5 mm. in standard length, which is probably that discussed by Longley and Hildebrand (1941: 145), although it differs in some proportions and counts from that description and has canine teeth. In contrast to my three specimens, this fish lacks head spines and serrations and keeled scales. These and other differences suggest that the fish here described are specifically distinct from *M. plumieri.*

I am most grateful to Mr. William W. Anderson, Mr. Jack W. Gehringer, Mr. Hugh M. Fields, and Dr. Giles W. Mead, U. S. Fish and Wildlife Service, to Dr. John C. Briggs, University of Florida, to Dr. Robert R. Miller, University of Michigan, and to Dr. William A. Gosline, University of Hawaii, for propitious suggestions; to Dr. J. L. B. Smith, Rhodes University, for information on the type of *D. incredibilis*; and to Dr. Leonard P. Schultz, U. S. National Museum, Dr. James E. Böhlke, Academy of Natural Sciences of Philadelphia, and Mr. E. Milby Burton, Charleston Museum, for the loan of specimens.

Dikellorhynchus tropidolepis, *sp. nov.*

Figures 1–6

Diagnosis: A *Dikellorhynchus* (Smith, 1956) with a rostral process bearing 2 pairs of lateral spines, a forked tail, and the body with keeled scales possessing 0 to 3 ctenii. Cheeks and opercles scaled. Dorsal IV or V-54 or 55. Anal I-51 to 53. Pectoral 16 or 17. Pelvic I-5. Gillrakers 3 or 4 + 1 + 8. Head 23.0 (22.9 to 24.2); depth at pectoral 15.0 (16.0

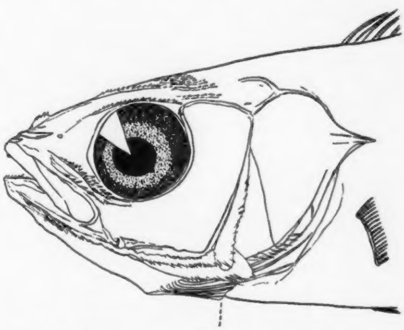

Fig. 2. Lateral view of head of *Dikellorhynchus tropidolepis,* 60.0 mm. in standard length.

Fig. 3. Dorsal view of head of *Dikellorhynchus tropidolepis,* 60.0 mm. in standard length.

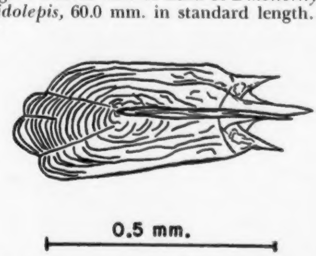

Fig. 4. Top view of scale taken from below lateral line on caudal peduncle of 60-mm. *Dikellorhynchus tropidolepis.*

to 14.8); snout to anal origin 40.0 (42.0 to 39.6) (in percent of standard length).

Description: Body elongate and slightly compressed. Snout moderately pointed. Lower jaw included. Two pairs of laterally extended rostral spines, the posterior pair the larger. Both pairs of spines lie over the snout at 60 mm. in standard length (S.L.), the anterior pair slightly projecting beyond the snout at 56.5 mm. S.L., and the anterior pair broken off and missing from the 55-mm. S.L. specimen, but apparently would have projected more in advance of the snout. A pair of elevated ridges, bearing four strong serrations, attached to the same rostral process as the rostral spines and located immediately behind them. A second less elevated pair of ridges originate just posterior to the pair described above and extend on top of the head to about the posterior margin of the pupil, and are serrated on that portion over the eye. A similar serrated ridge over each eye. A series of about 12 to 14 low, close-set, and generally parallel ridges on each side of top of head. Two similar ridges with stronger serrations separated from the most lateral of these on each side. Two parallel rows of strongly serrated ridges over the maxillary with a shorter row above the posterior portion of these. These 3 ridges apparently converge under the eye to become continuous with the ventral circumorgitals. A small group of strong serrations is located on the circumorbital bone near the anterio-dorsal margin of the preoperculum. Two parallel rows of serrated ridges on underside of each mandible. Opercle ending in a single strong spine. Spines on posterior and ventral margins of preoperculum and a row of smaller spines above these on the ventral margin. Spines on suboperculum and lower edge of operculum.

Gill membranes united on a vertical with angle of preoperculum. Gillrakers widely spaced, the one at the angle shorted and thinner than those adjacent.

Maxillary ending below front of eye. Teeth in upper jaw: At the front of each half of the jaw near the symphysis is a large recurved canine, a group of about 10 recurved canines behind this, and a patch of smaller canines behind these. From this anterior group of teeth and extending around each half of the jaw is a series of large canine teeth interspersed with smaller ones—the larger canines of this lateral series are smaller than the large canines of the frontal group. Teeth in lower jaw: At the front of each half of the jaw is a group of recurved canines of different sizes with the larger ones anterior. A single row of canines extends around each half of the jaw from this frontal group—these are of varying sizes, and the 4th, 5th, or 6th canine in this row is the largest in the jaw. The posterior canines of the lower jaw are larger than the corresponding ones of the upper jaw, but the canines in the frontal group are smaller than those of the frontal group of the upper jaw. The palate is edentate.

The dorsal fin is continuous. The first 4 or 5 elements of the dorsal fin and the first element of the anal fin are slender, flexible spines, and are shorter than the following soft-rays. The caudal is forked with all but the single most dorsal and most ventral principal rays branched. The pectoral and pelvic fins are inserted on an approximate vertical of the tip of the opercular spine and the dorsal fin origin. The first ray of the pectoral is unbranched; the others all appear to be branched. The spine of the pelvic is strong and all the pelvic soft-rays are branched. (Most of the fin rays are damaged or broken.)

Most of the scales are missing from the three specimens, but the scale pockets are easily discernible. They cover the cheeks forward to the mandibles, and the opercles. Scale pockets begin on top of the head directly behind the two groups of close-set serrated ridges and continue backward onto the caudal fin to about half-way between the caudal base and the fork of the tail, covering all the body except small scaleless areas under the insertion of the pelvics and behind the insertion of the pectorals. The paired fins and the dorsal and anal fins are apparently not scaled.

The scales have an oblique arrangement directed posterio-ventrally. The lateral line extends sinuously along the upper portion of the body from the cleithrum to under about the 40th dorsal ray, gradually descends to the midline of the body under about the 50th dorsal ray, and continues relatively straight onto the caudal fin to about two-fifths of the distance from the caudal base to the fork. No pores have developed in the lateral line scales, and each of these scales bears two keel-like structures which extend beyond a curved notch in the posterior margin of the scale base.

The scales are barely imbricated. Scales near the peduncle have three large ctenii (Fig. 4); scales over the major portion of the body have only one (Figs. 5 and 6); and a few scales that remained on the jugular region

had none—no scales remained on the head. Each scale has a thin keel set at a right angle to the base and inserted from the focus (or the point of convergence of the radii) to the insertion of the ctenii. The keels extend posteriorly above the ctenii (when present), and each keel has from one to three large serrations posteriorly on the top margin. Circuli are well formed only on the anterior portion of the scale, and from one to 6 partially or completely formed radii may be present.

There are 10 abdominal and 14 caudal vertebrae. The abdominal cavity extends to beneath the junction of the 9th and 10th abdominal vertebrae. The anus is situated nearly below the junction of the 6th and 7th vertebrae. The anal fin extends forward to beneath the junction of the 7th and 8th vertebrae.

The only pigmentation remaining on the 3 specimens consists of many small pigment spots on the brain (visible through the transparent skull in the area of the two groups of close-set serrated ridges).

Relationship: With respect to certain distinctive characters regarded to be of generic value this species is most closely related to *Dikellorhynchus incredibilis* Smith. These are the presence of rostral spines, close-set or laminate bony ridges on top of the head, serrated bony ridges on the head, preopercular spines, gill membranes united far forward, and keeled scales. Each of these characters serves to distinguish the genus *Dikellorhynchus* from *Malacanthus.* Another difference in the two genera is that the pectorals of *Dikellorhynchus* are inserted lower on the body and their tips do not extend back over the anal fin as they do in *Malacanthus.*

The scales of *D. tropidolepis* have 0 to 3 ctenii. Dr. Smith has written (personal communication) that a few of the scales of the type of *D. incredibilis* have a single posterior spicule at the scale base and some of the keels have 3 points similar to those in Figure 6.

The major characters that distinguish the two species of *Dikellorhynchus* are: 1) Lateral rostral spines, *D. tropidolepis* with two pairs, the anterior pair either slightly or not protruding beyond tip of premaxillary and *D. incredibilis* with one pair definitely protruding; 2) Cheek and operculum, scaled on *D. tropidolepis* and not scaled on *D. incredibilis*; 3) Spiny or serrated ridges on top and sides of head, converge toward but not to above snout on *D. tropidolepis* and converge to above snout on *D. incredibilis*; and 4) Caudal fin, forked on *D. tropidolepis* and rounded on *D. incredibilis.* By considering these 4 differences to be only of specific magnitude, an expansion of the generic characters of the genus is necessary for Smith had limited *Dikellorhynchus* in part by these characters. This combination of differences between the two species is not considered to warrant generic separation for reasons discussed later.

The single specimen of *D. incredibilis* was found on the beach after an onset of cold water, and Smith (1956: 57) suggested that it might live "at some depth, possibly in the 'Berycid' Zone." The dolphin stomach that contained the *D. tropidolepis* specimens also

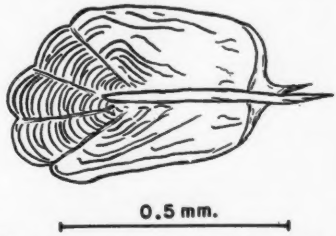

Fig. 5. Top view of scale taken from above lateral line and below about thirtieth dorsal ray of 60 mm. *Dikellorhynchus tropidolepis.*

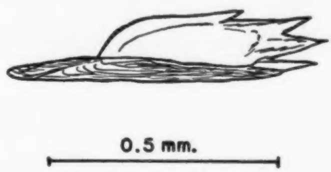

Fig. 6. Side view of scale taken from above lateral line and below about thirtieth dorsal ray of 60 mm. *Dikellorhynchus tropidolepis* (same scale as shown in figure 5).

contained larval or juvenile forms of species of *Holocentrus, Coryphaena, Xiphias, Dactylopterus, Gempylus, Sphaeroides,* and *Ophioblennius* (Anderson, Gehringer, and Cohen 1956: 54). Since these forms generally occur in pelagic surface waters where dolphin are known to feed, it is possible that *D. tropidolepis* is pelagic.

Holotype: USNM 158376; 56.5 mm. in standard length from the stomach of a dolphin, *Coryphaena hippurus,* which was caught by surface trolling during Cruise 2 of the M/V *Theodore N. Gill* for the U. S. Fish and Wildlife Service's South Atlantic Fishery Investigations, at approximately 34°28.5′ N., 74°38.5′ W., about 96 miles east of Cape Lookout Light, N. C., over a depth of 1800 fathoms, May 12, 1953.

Paratypes: USNM 158377, one specimen 60 mm. in standard length; and South Atlantic Fishery Investigations collection, one specimen 55 mm. in standard length; both taken with the holotype; partially cleared with 3 percent potassium hydroxide, stained with alizarine dye, and preserved in glycerine.

Derivation of the name: From the Greek *tropidos,* a keel, and *lepis,* a scale, in reference to the unique keeled scales.

Key to the genera of Malacanthidae (including Latilidae) of the Western North Atlantic

A. Total elements (spines and soft-rays) in dorsal fin 36 or less and in anal fin 27 or less. Vertebrae more than 24 .... (Branchiostegidae, Latilidae)

B. Total elements in dorsal fin about 22 and anal fin about 14 to 15. Adipose appendage at nape ...... *Lopholatilus* Goode and Bean 1879

BB. Total elements in dorsal fin 29 to 36 and in anal fin 21 to 27. No adipose appendage at nape .... *Caulolatilus* Gill 1862

AA. Total elements (spines and soft-rays) in dorsal fin 47 or more and in anal fin 39 or more. Vertebrae 24 .... (Malacanthidae)

C. Total elements in dorsal fin 47 to 62 and in anal fin 39 to 54 .... *Dikellorhynchus* Smith 1956, ... *Malacanthus* Cuvier 1829

Key to the Species of *Dikellorhynchus* and *Malacanthus*

A. Rostral spines present. Multiple spines on opercular bones in addition to large spine on operculum. Serrations on many bones of head. Scales keeled. Gill membranes connected on a vertical with angle of preoperculum .... *Dikellorhynchus*

B. One pair of rostral spines. Caudal fin rounded.................. *D. incredibilis* (Indian Ocean)

BB. Two pairs of rostral spines. Caudal fin forked................. *D. tropidolepis* (Western North Atlantic Ocean)

AA. No rostral spines. One strong spine on operculum; none on other opercular bones. No serrations on head. No keels on scales. Gill membranes connected posterior to a vertical with angle of preoperculum... *Malacanthus*

C. Total number of elements (spines and soft-rays) in dorsal fin 52 or less and in anal fin 42 or less .... *M. latovittatus* (Pacific and Indian Oceans)

CC. Total number of elements in dorsal fin 58 or more and in anal fin 49 or more

D. Caudal fin truncate. Two horizontal stripes on caudal. Head less than 22 percent of standard length .... *M. hoedtii* (Pacific and Indian Oceans)

DD. Caudal fin forked or falcate. A single horizontally elongated spot on dorsal half of caudal near base. Head more than 24 percent of standard length......... *M. plumieri* (Atlantic Ocean)

Comparison of the Species of *Dikellorhynchus* and *Malacanthus*

The genus *Malacanthus* is recognized as containing 3 species. Two of these, *M. hoedtii* and *M. latovittatus,* are Indo-Pacific forms and have been differentiated and described by Herre (1926: 220).

M. latovittatus has an elongated snout (Smith, 1950: pl. 13, fig. 384, and Weber and de Beaufort, 1936: fig. 105) similar to that of *M. plumieri* and contrasting with the shorter snout of *M. hoedtii.* The ranges of dorsal rays, IV to VI-43 to 46, and of anal rays, I-38 to 41, however, completely separate *M. latovittatus* from the other two species. It has been identified from Polynesia, Melanesia, and Indonesia, the Philippines (Weber and de Beaufort, 1936: 552) and west and south in the Indian Ocean to Inhaca Island (Smith, 1955: 6). Because of the above meristic separation, *M. latovittatus* does not further concern the relationships of the specimens of *Dikellorhynchus* and the other two species of *Malacanthus.*

M. hoedtii (Fig. 7) has been identified from the Hawaiian Islands, Micronesia, and the Philippines, Melanesia and New Zealand, Indonesia, (Weber and de Beaufort, 1936: 550), and west and south in the Indian Ocean to Madagascar and Bazaruto Bay (Smith, 1955: 6).

M. plumieri (Figs. 8, 12, and 13) has been reported from Bermuda (Bean, 1906: 83 and Beebe and Tee-Van, 1933: 172), on edge of Gulf Stream off Charleston, S. C., and Key West, Fla. (Fowler, 1945: 213 and 312), Tortugas, Fla. (Longley and Hildebrand, 1941: 145), Port Isabel and Port Aransas, Texas (Baughman, 1947: 280 and 1950: 251), *Oregon* Sta. 591, 23°24′ N., 87°09′ W., on Campeche Bank and *Oregon* Sta. 788, 23°37′ N., 84°30′ W., northwest of Cuba (Springer and Bullis, 1956: 88), *Oregon* Sta. 1046, 22°40′ N., 91°42′ W., Cay Arenas (Mr. David K. Caldwell, personal communication and photograph), about 25 mi. south of Pensacola, Fla. (personal record), the Bahamas (Fowler, 1919: 151 and Parr, 1930: 67), Cuba (Jordan and Evermann, 1898: 2275), Cay Sal Bank (Breder, 1927: 84), Haiti (Fowler, 1937: 313), Jamaica (Fowler, 1939: 15), St. Croix (Blosser, 1909: 300 and Nichols, 1930: 371), Dutch West Indies (Metzelaar, 1919: 70), Roncador Bank, St. Andrews Island, and New Providence Island (Fowler, 1944: 89, 154, and 447), Brazil (Fowler, 1941: 169, see synonymy), and As-

cension Island (Norman, 1935: 56). Mr. G. Palmer reported (personal communication) that there are two specimens of *M. plumieri*, 347 and 468 mm. in standard length, from Ascension in the British Museum (Natural History).

The data in Table I were compiled from the published account of *D. incredibilis* (Smith, 1956) and personal communication on the type from Dr. Smith; notes were furnished by Mr. E. M. Burton of the Charleston Museum on the largest recorded specimen of *M. plumieri*, taken by fishing smack OSPREY, from ESE of Charleston, S. C., in 27–30 fathoms, Sept. 25, 1950, 560 mm. S.L. (685 mm. total length, specimen not preserved); and from examination of the following specimens: *D. tropidolepis*, the holotype and paratypes. *M. hoedtii*, ANSP 28025, Hawaiian I., 164 mm. S.L.; ANSP 28166-7, Hawaiian I., 195 and 203 mm. S.L.; ANSP 29730-1, Honolulu, Hawaiian I., 197 and 252 mm. S. L. *M. plumieri*, USNM 116836, Tortugas, Fla., collector W. H. Longley, 55.5 mm. S.L.; USNM 9819, Cuba, collector Poey, 174 mm. S.L.; USNM 123657, off Havana, Cuba, Nov. 4, 1945, collector L. R. Rivas, 198 mm. S.L.; South Atlantic Fishery Investigations specimen, caught bait-fishing on bottom, about 25 mi. south of Pensacola, Fla., in about 25 fathoms, by Mr. Broyles Yon, Oct. 3, 1955, 405 mm. S.L.; ChM 38.85, taken by fishing smack HAROLD, 60 mi. ESE of Charleston, S. C., April 30, 1938, 505 mm. S.L.

Certain morphometric growth changes in *M. plumieri* are evident from comparison of Figures 8, 12, and 13 and from Table I. From the smallest to the largest sizes examined, relative to body (standard) length: The pectorals increase, then decrease in length. The caudal fin becomes very falcate, then becomes less so. The eye diameter decreases. The snout length increases. The body depth (greatest) increases.

The only meristic change in *M. plumieri* with increase in body size is a decrease in number of the lower limb gillrakers—apparently the rakers tend to degenerate from the origin of the lower limb toward the angle.

A few characters of this group warrant clarification: All of the scales of *M. plumieri* and *M. hoedtii* do not possess ctenii—those anterior to a diagonal encircling the body from the dorsal fin origin to the anal fin origin are essentially cycloid, and the scales of *D. tropidolepis* are generally similar. There are small scaleless areas behind the pectoral and pelvic fins in these three species. The first element of the anal fin of these three species is a flexible spine. The anterior 4 or 5 elements of the dorsal fin of *D. tropidolepis* and the first 5 (possibly 4 to 6) elements of *M. plumieri* are flexible spines; but on specimens of *M. hoedtii* examined, only the first 2 elements of the dorsal fin are spines (this latter is contrary to all published accounts I have reviewed).

Relationships of the 4 species concerned can be drawn for morphometric and meristic characters in Table I.

The similarities of *D. tropidolepis* and *D. incredibilis* that separate them from *Malacanthus* species have been discussed. In one feature, the absence of scales on the cheeks and opercles, *D. incredibilis* is distinct from

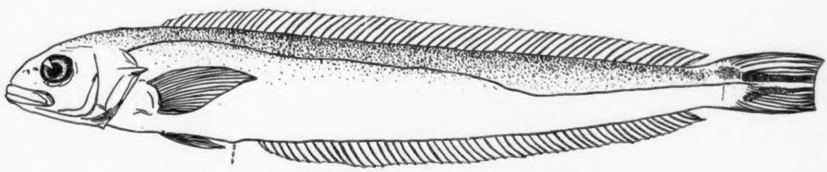

Fig. 7. *Malacanthus hoedtii*, 167 mm. in standard length.

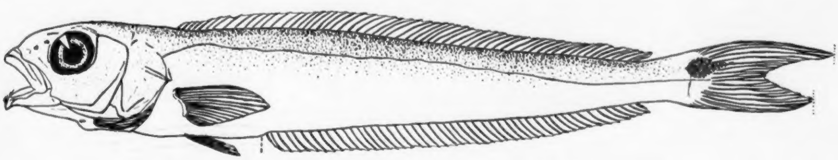

Fig. 8. *Malacanthus plumieri*, 55.5 mm. in standard length.

the others. In many other characteristics, similarities of *D. tropidolepis* and *M. plumieri* are directly contrasted with similarities that relate *D. incredibilis* and *M. hoedtii*: *D. tropidolepis* and *M. plumieri* have longer head lengths, snout lengths, and snout to dorsal, anal, and paired fin insertions, and greater body depths than *D. incredibilis* and *M. hoedtii*. The forked tail of *D. tropidolepis* and the falcate tail of *M. plumieri* contrast with the rounded tail of *D. incredibilis* and truncate tail of *M. hoedtii*.

The scales of the 60 mm. *D. tropidolepis* (Fig. 5) and the 55.5 mm. *M. plumieri* (Fig. 11) are very similar in basic structure, except for the keel of *Dikellorhynchus*. The scales in the above two figures were taken from about the same position on each fish. The 5 ctenii on the *M. plumieri* scale, compared with only one ctenii on the *D. tropidolepis* scale, suggests that the scale of the former had developed to a further degree, since the number of ctenii increased on progressively larger sizes of *M. plumieri* (assuming a similar increase in number of ctenii with increase in body size in *D. tropidolepis*). As many as 141 ctenii and ctenii-bases were counted on a scale of the 505 mm. *M. plumieri* (curiously, not a single scale could be found on this fish that did not have a regenerated central portion).

The 3 specimens of *D. tropidolepis* were

TABLE I

MORPHOMETRIC AND MERISTIC VALUES OF SPECIMENS OF *Dikellorhynchus tropidolepis*, *Malacanthus plumieri*, *D. incredibilis*, AND *M. hoedtii*

[ASTERISKED ITEMS ARE APPROXIMATE VALUES]

	Dikellorhynchus tropidolepis			*Malacanthus plumieri*					*Dikellorhynchus incredibilis*	*Malacanthus hoedtii*				
Standard length, mm.	55.0	56.5	60.0	55.5	174	198	406	505	*59.8	164	195	197	203	252
Fork length, mm.	—	63.0	65.5	61.9	191	216	441	545	—	185	219	220	227	281
Total length, mm.	64.0	65.5	*69.5	*66.5	223	*236	490	600	70.0	187	221	224	228	283
Percent of Standard Length:														
Head length	22.9	23.0	24.2	25.2	24.7	25.5	25.9	27.3	20.5	21.3	21.3	21.1	21.4	21.0
Eye diameter	6.2	6.0	6.5	7.4	5.7	6.3	4.3	3.8	5.8	5.5	5.6	5.3	6.0	4.8
Snout length	5.6	5.8	6.3	7.0	9.8	9.7	12.2	13.8	5.7	6.4	6.7	6.9	6.2	6.7
Postorbital head length	11.1	10.8	11.2	11.0	9.8	10.1	10.5	10.8	8.8	9.8	10.0	10.2	10.1	9.9
Maxillary length	6.5	6.7	7.5	9.0	8.6	9.1	9.8	10.7	—	7.9	7.9	7.6	8.1	7.6
Dorsal base length	—	69.9	71.7	69.5	72.4	68.2	69.0	68.5	72.0	72.9	74.4	73.6	74.9	74.2
Anal base length	—	59.2	57.5	55.8	56.3	55.5	57.1	57.8	56.0	60.1	61.0	60.4	59.6	60.3
Pectoral length	11.6	*10.1	*10.7	12.6	13.5	14.4	12.8	11.7	9.0	14.6	14.4	14.5	15.5	*9.9
Pelvic length	*8.5	*7.4	*8.5	9.4	9.2	8.3	8.7	8.6	6.8	9.1	8.7	8.4	8.6	8.3
Snout to dorsal origin	22.9	22.3	21.2	25.0	23.6	25.3	24.1	25.7	22.0	22.0	22.6	21.6	20.9	21.2
Snout to anal origin	42.0	40.0	39.6	41.4	39.1	40.4	39.7	40.0	33.0	35.1	34.4	36.8	35.7	33.9
Snout to pectoral insertion	24.0	23.2	23.5	25.6	24.7	26.8	26.4	26.9	—	20.7	20.5	21.3	21.2	20.6
Snout to pelvic insertion	26.4	25.5	25.7	27.9	27.9	25.0	30.8	29.1	—	22.3	22.3	22.3	22.9	22.6
Head depth (through pupil)	—	10.4	12.8	14.1	12.4	11.8	13.1	14.5	—	11.6	11.0	9.6	10.3	11.3
Body depth (greatest)	—	15.4	15.3	15.5	15.2	*16.7	*15.5	18.0	12.4	14.6	15.6	14.7	*13.8	*14.7
Peduncle depth	—	6.5	6.0	6.5	6.3	6.3	6.8	6.8	4.0	5.6	5.4	5.3	5.2	5.6
Interorbital width (bony)	4.9	5.7	5.5	6.1	4.9	4.8	7.0	7.8	4.0	5.2	5.2	4.8	5.4	4.8
Body width (greatest)	—	10.3	11.5	8.6	9.[illegible]	*9.1	11.3	10.4	—	10.1	9.5	10.4	9.1	9.9
Dorsal	V-55	V-54	IV-55	V-54	V-56	V-55	V-57	V-57	(57)	II-58	II-58	II-58	II-59	II-56
Anal	I-53	I-52	I-51	I-48	I-51	I-50	I-53	I-53	(49)	I-52	I-52	I-51	I-51	I-49
Pectoral	17	*16	17	17	17	17	17	16	17	16	16	*16	16	16
Pelvic	I-5	I-5	I-5	I-5	I-5	I-5	I-5	I-5	I-5	I-5	I-5	I-5	I-5	I-5
Caudal: Principal	8 + 7	8 + 7	8 + 7	8 + 7	8 + 7	8 + 7	8 + 7	8 + 7	(15)	8 + 7	8 + 7	8 + 7	8 + 7	8 + 7
Secondary	11 + 11	—	13 + 12	—	—	—	—	—	—	—	—	—	—	—
Gill rakers: Upper	3	4	3	3	4	4	4	4	7	6	4	6	3	4
At angle	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Lower	8	8	8	8	6	6	5	3	11	9	*7	8	7 & 9	*7
Scales: Diagonal rows	—	*158	*142	*135	134	*139	150	144	115	*120	129	*125	132	129
In lateral line	—	—	*141	*155	142	*144	151	151	153	177	173	179	168	163
Branchiostegals	6	6	6	6	6	6	6	6	—	*6	6	*6	6	6

taken about 120 miles north of the known range of *M. plumieri,* and the type of *D. incredibilis* was obtained about 600 miles south of the recorded range of *M. hoedtii.* Both of these collection sites are in areas that are affected by currents that move away from areas where *Malacanthus* species are known to occur (the Gulf Stream in the Western Atlantic and the Agulhas Stream off Southwest Africa), and presumably the *Dikellorhynchus* specimens could have originated in waters where *Malacanthus* are known to occur.

Because only 4 specimens of *Dikellorhynchus* are known and all are about the same size, and because the early life history of *Malacanthus* is unknown, four suppositions may be projected to account for the relationships of the 2 genera: 1) That the *Dikellorhynchus* species are juvenile or adult forms as they have been described. 2) That the *Dikellorhynchus* specimens are larval forms of yet undescribed adults. 3) That the *Dikellorhynchus* specimens are aberrant growth stages of *M. plumieri* and *M. hoedtii.* 4) That *D. tropidolepis* and *D. incredibilis* are protracted larval stages of *M. plumieri* and *M. hoedtii,* respectively. These are discussed in order.

The first two of the above suppositions, assuming that *Dikellorhynchus* is a valid genus, have to be adopted in describing the specimens as new species. This seems logical in view of the spines and serrations on the head and the keeled scales of *Dikellorhynchus* and because of comparative sizes of the *Dikellorhynchus* specimens and of small *Malacanthus* specimens that have been ex-

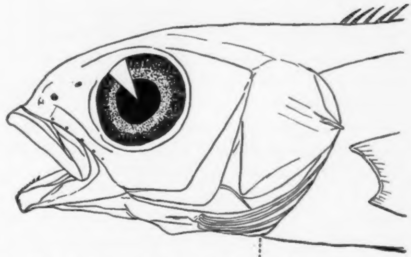

Fig. 9. Lateral view of head of *Malacanthus plumieri,* 55.5 mm. in standard length.

Fig. 10. Dorsal view of head of *Malacanthus plumieri,* 55.5 mm. in standard length.

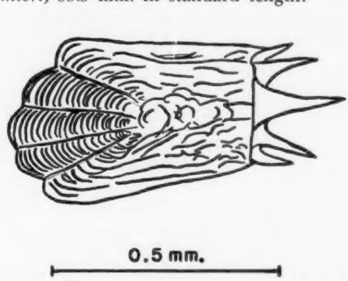

Fig. 11. Top view of scale taken from above lateral line and below about thirtieth dorsal ray of 55.5 mm. *Malacanthus plumieri.*

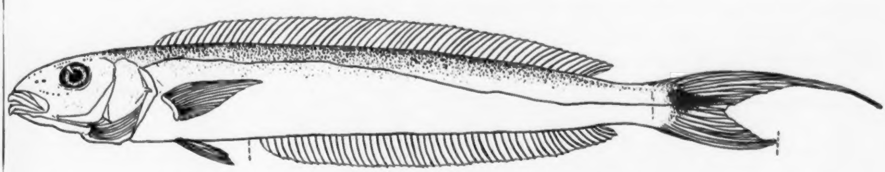

Fig. 12. *Malacanthus plumieri,* 178 mm. in standard length.

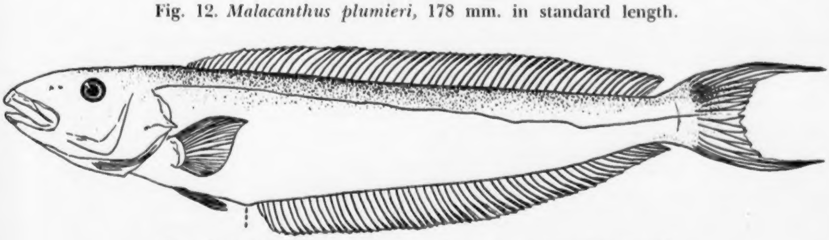

Fig. 13. *Malacanthus plumieri,* 505 mm. in standard length.

amined: The largest *D. tropidolepis* is larger than the smallest *M. plumieri* examined; and Dr. Smith has obtained a specimen of *M. hoedtii* 75 mm. in total length with very distinct parallel dark bars on the caudal (personal communication), which specimen is only 5 mm. longer in total length than the type of *D. incredibilis.* This is also supported by the more anterior joining of the gill membranes and the lower insertions of the pectorals of *Dikellorhynchus.* Smith (1956: 57) favored the first possibility, and expressed the opinion that his type was not a larval specimen. I believe the second of these two possibilities to be more tenable, primarily because of the posterior regression of the anterior pair of lateral rostral spines from 55 to 60 mm. S.L. in *D. tropidolepis* and because of the incompletely formed lateral line scales of this species.

The last two suppositions are suggested by the several characters that relate *D. tropidolepis* to *M. plumieri* and *D. incredibilis* to *M. hoedtii* and that thereby distinguish these two groups of separate geographic occurrence. This implies that *Dikellorhynchus* is only a growth stage of *Malacanthus.* The third of the above possibilities lacks substance when it is considered that 3 specimens of *D. tropidolepis,* all of slightly different sizes, were swallowed by one dolphin. The fourth possibility has a dual implication to the effect that all *Malacanthus* have a *Dikellorhynchus* stage in possessing head spines and serrations and keeled scales as larvae, and that the size of transformation from larva to juvenile may vary over an appreciable range of body size. There is precedence for the speculation that the transition from the larval to the juvenile form may be responsive to or dependent upon a change of environment, that the larva may continue to develop as such until the environmental change occurs, that this environmental change may occur at different times of development for individual fish, and, consequently, that the body size at transformation may vary greatly. Breder (1949: 296) described such a differential larval-juvenile transformation for *Acanthurus chirurgus* (Bloch) (= *A. hepatus* Linnaeus) in which he found the transparent "*pawnee*" larval stage specimens as large as 29 mm. in length and transformed juvenile specimens as small as 10 mm. in standard length. Breder inferred that the planktonic larval forms transformed when they reached a littoral habitat. *Malacanthus* species apparently inhabit the littoral zone of not too great depts. Beebe and Tee-Van (1933: 172), stating that the species is common in Bermuda, said it is found from close inshore on sand and grass to the deeper waters of 90 to 100 fathoms. The unknown larval forms of the species of *Malacanthus* may be pelagic *Dikellorhynchus* types.

The fourth supposition is the most intriguing to a student of fish development and cannot be entirely disregarded, but the second is the strongest on the basis of extant evidence and must be accepted until the early life histories of the species of *Dikellorhynchus* and *Malacanthus* become known.

Addendum—Additional specimens of *Dikellorhynchus tropidolepis* were found and identified after the manuscript was in galley. One entire specimen, 54 mm. in standard length; one specimen bitten apart, approximately 50 mm. S.L.; and the tail or trunk and tail portions of 13 others, from about 45 to 55 mm. S.L., were in the stomach contents of a *Coryphaena hippurus* taken by surface trolling during Cruise 5 of the GILL for the U. S. F. W. S. South Atlantic Fishery Investigations: taken at approximately 26°21′ N., 76°46′ W., about 16 miles northeast of Nassau, Bahamas, B. W. I., January 25, 1954. The specimens are in the collection of the South Atlantic Fishery Investigations. The anterior pair of rostral spines of the specimens of 54 and about 50 mm. S.L. are slightly more in advance of the snout than those of the 56.5-mm. paratype. The dolphin predator had other stomach contents consisting of exocoetid, scrombrid, and plectognath remains, fish eggs, crustaceans, and sargassum—which tend to indicate that it had been feeding near the surface.

LITERATURE CITED

ANDERSON, WILLIAM W., JACK W. GEHRINGER, AND EDWARD COHEN. 1956. Physical oceanographic, biological, and chemical data, South Atlantic coast of the United States, *Theodore N. Gill* Cruise 2. *U. S. Fish and Wildl. Serv., Spec. Sci. Rept.: Fish. No. 198, p. 1–270, figs. 1–20.*

BAUGHMAN, J. L.
1947. Fishes not previously reported from Texas, with miscellaneous notes on other species. COPEIA, *1947(4): 280.*
1950. Random notes on Texas fishes. Part II. *Texas Jour. Sci., 2(2): 242–63.*

BEAN, TARLETON H. 1906. A catalogue of the fishes of Bermuda, with notes on a collection made in 1905 for the Field Museum. *Field Mus. Nat. Hist., Zool. Ser., 7(2): 21–89, figs. 1–14.*

BEEBE, WILLIAM AND JOHN TEE-VAN. 1933. Field book of the shore fishes of Bermuda. *G. P. Putnam's Sons, N. Y., xiv + 337 p., text-figs. and pls.*

BLOSSER, CHRISTIAN B. 1909. Reports on the expedition to British Guiana of the Indiana University and the Carnegie Museum, 1908. Report No. 3. The marine fishes. *Ann. Carnegie Mus., 6(1): 295–300, pls. X–XII.*

BREDER, C. M., JR.

1927. Scientific results of the first oceanographic expedition of the "Pawnee," 1925. Fishes. *Bull. Bingham Oceanogr. Coll., 1(Art. 1): 1–90, figs. 1–36.*

1949. On the taxonomy and the postlarval stages of the surgeon-fish, *Acanthurus hepatus*. COPEIA, *1949(4): 296.*

FOWLER, HENRY W.

1919. Notes on tropical American fishes. *Proc. Acad. Nat. Sci. Phila., 71: 128–55.*

1937. A collection of Haytian fishes obtained by Mr. Stanley Woodward. *Proc. Acad. Nat. Sci. Phila. 89: 309–15, 1 fig.*

1939. Notes on fishes from Jamaica with descriptions of three new species. *Notulae Naturae, No. 35, p. 1–16, figs. 1–6.*

1941. A list of the fishes known from the coast of Brazil. *Arquiv. Zool. Sao Paulo, 3(Art. 6): 115–184.*

1944. Results of the fifth George Vanderbilt Expedition (1941). The fishes. *Monogr. Acad. Nat. Sci. Phila., No. 6, p. 57–583, figs. 1–268, pls. 1–20.*

1945. A study of the fishes of the Southern Piedmont and Coastal Plain. *Monogr. Acad. Nat. Sci. Phila., No. 7, vi + 408 p., figs. 1–313.*

HERRE, ALBERT W. 1926. Four rare Philippine fishes. *Philippine Jour. Sci., 31: 217–225, fig. 1, pls. I–II.*

JORDAN, DAVID STARR AND BARTON WARREN EVERMANN. 1898. The fishes of North and Middle America ... *Bull. U. S. Nat. Mus., No. 47, Pt. III, p. i–xxiv + 2183a–3136.*

LONGLEY, WILLIAM H. AND SAMUEL F. HILDEBRAND. 1941. Systematic catalogue of the fishes of Tortugas, Florida. *Carnegie Inst. Washington Pub. No. 535 (Pap. Tortugas Lab., Vol. 34), xiii + 329 p., pls. 1–34.*

METZELAAR, J. 1919. Report on the fishes, collected by Dr. J. Boeke, in the Dutch West Indies, 1904–1905, with comparative notes on fishes of tropical West Africa. *Rapport Viss. Ind. Zee. Kolonie Curacao, 2(Pt. 2): 1–316, figs. 1–64.*

NICHOLS, J. T. 1930. The fishes of Porto Rico and the Virgin Islands. Pomacentridae to Ogcocephalidae. *N. Y. Acad. Sci., Sci. Serv. Porto Rico, 10(Pt. 3): 299–399, figs. 175–314.*

NORMAN, J. R. 1935. Coast fishes. Part I. The South Atlantic. *Discovery Repts., 12: 1–58, figs. 1–15.*

PARR, ALBERT EIDE. 1930. Teleostean shore and shallow-water fishes from the Bahamas and Turks Island. *Bull. Bingham Oceanogr. Coll., 3(Art. 4): 1–148, figs. 1–38.*

SMITH, J. L. B.

1950. The sea fishes of Southern Africa. *Central News Agency, Ltd., Cape Town, xvi + 550 p., figs. 1–1232, pls. 1–103.*

1955. New species and new records of fishes from Mocambique. Part I. *Memorias do Museu Dr. Alvaro de Castro, No. 3, p. 1–27, figs. 1–32, pls. I–III.*

1956. An extraordinary fish from South Africa. *Ann. Mag. Nat. Hist., Ser. 12, 9: 54–57, pl. I.*

SPRINGER, STEWART AND HARVEY R. BULLIS, JR. 1956. Collections by the *Oregon* in the Gulf of Mexico: List of crustaceans, mollusks, and fishes identified from collections made by the exploratory fishing vessel *Oregon* in the Gulf of Mexico and adjacent seas, 1950 through 1955. *U. S. Fish and Wildl. Serv., Spec. Sci. Rept.: Fish. No. 196, p. 1–134.*

WEBER, MAX AND L. F. DE BEAUFORT. 1936. The fishes of the Indo-Australian Archipelago. VII. Perciformes (continued). *E. J. Brill, Ltd., Leiden, xvi + 607 p., figs. 1–106.*

SOUTH ATLANTIC FISHERY INVESTIGATIONS, U. S. FISH AND WILDLIFE SERVICE, BRUNSWICK, GEORGIA.

The Discovery in Florida of the Cyprinodont Fish, *Rivulus marmoratus*, with a Redescription and Ecological Notes

ROBERT W. HARRINGTON, JR.[1] AND LUIS RENÉ RIVAS[2]

THE collection in 1955 of a series of *Rivulus marmoratus* Poey along Indian River, Florida by W. L. Bidlingmayer and the senior author following the revival of its name by the junior author (Rivas, 1945) establishes for this species both a local habitation and a name for the first time since it was described 75 years before (Poey, 1880). Besides the Indian River material (34 specimens from six localities), two specimens of *Rivulus* from the collection of the junior author, taken in 1950 in Biscayne Bay, and the single, first and only other specimen of *Rivulus* recorded from the United States, taken in 1927 at Key West by R. O. Van Deusen (ANSP 71320) and identified as *R. cylindraceus* (Fowler, 1928), have been examined by the present writers and found to be examples of *R. marmoratus*. Thus, 37 United States representatives of *R. marmoratus*, all from

[1] Florida State Board of Health, Vero Beach, Florida.
[2] University of Miami, Coral Gables, Florida.

Florida, are now extant. Prior to this, only two individuals assigned to this species (USNM 37429 and USNM 123000) were known to the literature. Cogent evidence was adduced for equating these with Poey's original (lost) types of *R. marmoratus,* which for some years had been synonymized erroneously (see below) with *R. cylindraceus* Poey, and they have been designated lectotypes (Rivas, 1945).

Poey's description is ambivalent as to locality but prophetic: "I have in my possession two specimens which I received from Dr. Rafael Arango; and they are from Cuba, if [*sic*] they don't exist in the United States, whence Professor Gill has sent me some species of Cyprinodontes" (translation of Rivas, 1945). Extensive collecting by the junior author throughout the supposed geographic range (Cuba, including the Isle of Pines) yielded *R. cylindraceus* but no *R. marmoratus.* On the other hand, J. T. Nichols recently showed the senior author three specimens (AMNH 3364 C 2/4 and AMNH 3425 C 2/4) taken in 1912 in brackish water at Havana, Cuba, and identified by him as *R. marmoratus.* These specimens though somewhat faded clearly have the same markings as the Indian River specimens and the higher scale count characteristic (see Rivas, 1945) of *R. marmoratus* but not of *R. cylindraceus,* and Mr. Nichols is of the opinion (personal communication to the senior author) that *R. marmoratus* is a brackish-water, and *R. cylindraceus,* a freshwater form. Similar markings and as high a scale count are found in a small collection (USNM 164438) made by Jaume in 1955 at Havana, Cuba, in a pond about 100 m. from the sea and ½ km. east of the Cojimar River, and also in a solitary specimen taken in January 1956 by Louis A. Krumholz and Priscilla Rasquin in a salt pond at Caloo, Mangrove Key, Bimini, B. W. I., and now in the American Museum of Natural History. Since this paper was submitted for publication, Carl L. Hubbs (personal communication) called our attention to another solitary specimen of *Rivulus* (USNM 102083), 30 mm. in standard length, taken by Paul Bartsch in 1912 at Smith's place at the southeast corner of Andros Island. This was tentatively assigned a new species name by Hubbs and Luis Howell-Rivero (unpublished) before the present junior author rediscovered the types of *Rivulus marmoratus.* The present senior author during the absence abroad of the junior author examined this specimen and found no significant departures from the equivalent characters of *Rivulus marmoratus* as now understood and enumerated in this paper.

The presumption is that the Bimini as well as the Cuban and Andros Island specimens represent *R. marmoratus.* The redescription below of *R. marmoratus* based on the freshly collected Indian River series should provide the basis for a more definitive determination of additional island specimens.

The authors are indebted to Leonard P. Schultz, Curator of Fishes, United States National Museum for the loan of one of Poey's specimens and the Andros Island specimens, for help in locating other material and for the photograph of a specimen deposited by us in the museum, to James E. Böhlke, Department of Ichthyology and Herpetology, The Academy of Natural Sciences of Philadelphia, for locating and loaning ANSP 71320, to C. M. Breder, Jr. and J. T. Nichols, of the American Museum of Natural History, for access to other specimens, to Carl L. Hubbs and Luis Howell-Rivero for the privilege of citing the Andros Island record, and to the following from the staff of the Entomological Research Center, Florida State Board of Health: Maurice W. Provost, Director, for encouraging and facilitating this publication, Erik Tetens Nielsen, for photographs, Willem Janse, for rendering the drawings, Nina C. Branch and Robert L. Blickle for identifying stomach contents.

Rivulus marmoratus Poey

Rivulus marmoratus Poey, 1880: 284 (original description; compared with *R. cylindraceus*).—Jordan, 1887: 564 (listed).—Garman, 1895: 134 (erroneously synonymized with *R. cylindraceus*).—Jordan and Evermann, 1896: 633 (description, after Poey),—Regan, 1912: 500 (erroneously synonymized with *R. cylindraceus*), —Myers, 1927: 121 (erroneously synonymized with *R. cylindraceus*), —Fowler, 1928: 451 (new specimen described; erroneously referred to *R. cylindraceus*), —Jordan, Evermann, and Clark, 1930: 179 (erroneously synonymized with *R. cylindraceus*), —Rivas, 1945: 95 (redescription of presumptive types of Poey and their designation as lectotypes of *R. marmoratus* Poey.).

The description following (compare Plate I) is based on 20 specimens of *R. marmoratus,* ranging from 8.7 mm. to 39.7 mm. in standard length selected from the series collected along Indian River in 1955 by Mr. Bidlingmayer and the senior author. Characters involving

allometric growth are expressed by means of regressions (Figs. 1–3). Isometric characters are expressed in thousandths of the standard length, the range of variation of the character being given first, followed in parentheses by the arithmetic mean. For measuring and counting methodology, see Rivas (1944: 41).

Predorsal length, 738–773 (758); prepelvic length, 525–586 (551); preanal length, 605–647 (622); greatest width of body, 161–197 (175); snout length, 54–70 (63); width of mouth, 85–117 (101); interorbital width, 115–150 (136); width of head, 199–234 (212); length of anal fin, 232–258 (245); length of

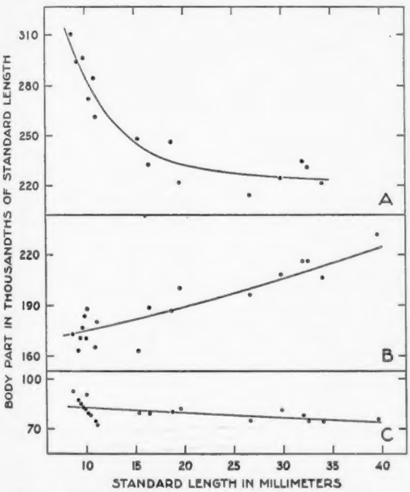

Fig. 1. Regressions on the standard length, of middle caudal rays (A), greatest depth of body (B), orbit diameter (C). Four specimens, 9.4 mm., 9.6 mm., 10.0 mm., and 10.1 mm. in standard length, with frayed caudal fins, were not measured for length of middle caudal rays.

pectoral fin, 181–214 (195); length of dorsal base, 85–116 (100).

Fin rays: dorsal 8 (14 specimens), 7 (6); anal 10 (19), 11 (1); pectoral 12 (1), 13 (16), 14 (3); pelvics 6 (20); branched caudal 10–16 in specimens 15.0–39.7 mm. in standard length, with the larger counts in the larger specimens.

Scales: transverse rows 47–51 (48.8); longitudinal rows 10–13 (11.7); predorsal 34–39 (36.6). The exposed diameters of the ventral body scales about half those of the dorsolateral ones.

General coloration in nature is deep maroon, tending in alcohol toward pale reddish brown. Dorsum is uniform dark brown, but

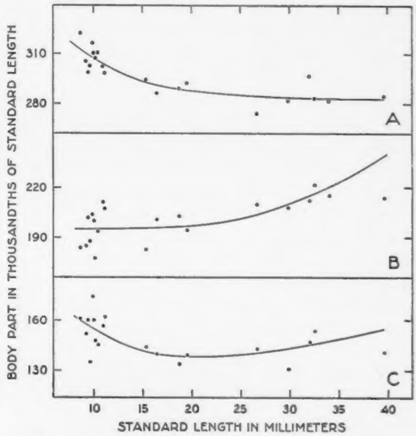

Fig. 2. Regressions on the standard length, of prepectoral length (A), origin of dorsal fin to origin of anal fin (B), length of anal base (C). One specimen 34.0 mm. in standard length with broken anal base was not measured for length of anal base.

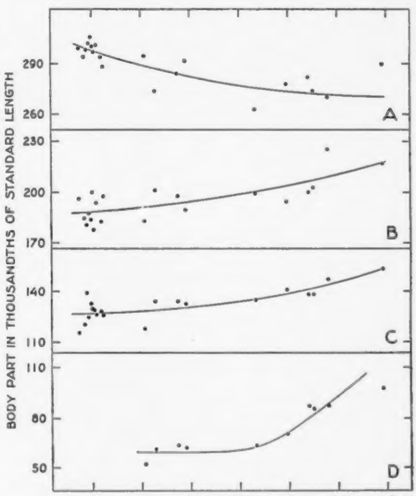

Fig. 3. Regressions on the standard length, of head length (A), length of dorsal fin (B), least depth of caudal peduncle (C), and length of pelvic fin (D).

with scale margins thinly edged with paler; scale surfaces when viewed under magnification show a dark dendroid reticulation over lighter ground color. From the ventral aspect, an abruply demarked pale venter stands out,

including the lower two-thirds of opercles and the cheeks up to the edge of the orbits, the gular region up to the lower lip, and an area behind marked off on either side by a straight line from the middle of the pectoral base to the anus. This entire area is pale cream color, lightly stippled with pale reddish brown and paved with minute diamonds defined by the dark edges of the small scales. Ground color of the sides is the same maroon or red brown as the dorsum, gradually paling ventrad but still dark enough to contrast sharply at the line of demarkation with the much lighter venter. Diffuse, light buff blotches are superposed on the ground color, giving it a checkered appearance. Under closer inspection, the blotches appear disposed in diagonal rows parallel with the scale row from dorsal origin to anal origin and with usually three blotches per row. A random scattering of dark (red brown to black), sharply defined dots of slightly variable diameter pepper the sides from the posterior half of the operculum to the caudal ocellus and from mid-lateral level to the edge of the venter in front and to the mid-ventral line behind the anus. The diameter of the conspicuous ocellus at the posterodorsal angle of the caudal peduncle, is one-third the depth of the peduncle; its large "pupil" is of the same color as the dorsum and is surrounded by a cream-colored "iris" brighter and yellower than the venter. Ontogenetically, the ocellus gradually forms from a row of dark and light dots, attaining usually to reversed C-shape, infrequently, to O-shape (Pl. I, A–C). A dark, roundish humeral spot, equal in diameter to the outer diameter of the caudal ocellus, lies just above the pectoral base; one-third of it extends halfway down behind the pectoral axil. This spot is infrequently surrounded by a thin, light "iris", to qualify as an ocellus, but more frequently it is merely a spot (thus resolving an old controversy, see Rivas, 1945: 96). The unpaired fins are mottled with cream and brown, to give them a banded marbling of less than the maximum color intensity elsewhere on the body. The paired fins are pale and essentially unmarked, save for the bases of the pectorals, the upper halves of which may have dark blotches apparently related to the humeral spot.

Lower jaw is notable for its considerable protrusibility. Upper lip conspicuously small and overreached by tubular anterior nares, projecting forward on either side. Orbits are so far forward that only a thin preorbital strip separates eye margin and mouth angle; their upper margins are level with the dorsal surface of the head. Pelvic fins are undeveloped in specimens as large as 9.2 mm. in standard length; pelvic buds occur at 9.6 mm. and differentiated pelvic fins in specimens as small as 10.3 mm. Teeth loosely fastened and irregular in size. Upper jaw has an outer row of about 14 conical, curved teeth (three enlarged on either side) enclosing smaller, inconspicuous teeth irregularly disposed in several rows so as to approximate a band; the hind (innermost) row also has three enlarged teeth on each side. Lower jaw has 10 large teeth in the outer row and irregular rows of minute teeth behind as in the upper jaw, but with no conspicuously enlarged teeth in the back row. There are nine gillrakers on the lower limb, including rudiments.

Of the specimens of *Rivulus marmoratus* from along Indian River, 32 were collected in 1955 by spot poisoning with emulsified rotenone dispensed as a spray and 2 in 1956 in minnow traps. The most remote collecting sites were 15.75 miles apart, about equidistant north and south of Ft. Pierce Inlet. In Indian River County, one was taken 8.5 miles north of the inlet on the west bank, and two just north of the St. Lucie County line on the east bank; in St. Lucie County, 31 were collected from 2.25 to 7.25 miles south of the inlet along the east bank. All 1955 collections were made in anti-mosquito ditches[3] traversing mangrove swamps and with one exception (½ mile inshore) within 200–850 feet of either an embayment or the unindented shoreline of Indian River; the two specimens trapped in 1956 were taken in inundated marsh during the period of high water, in September. It may be seen from the ranges in standard and total lengths (latter in parentheses) that juveniles comprise the largest single collection (of August 24) and that the other collections are composed of adults or subadults:

April	26	2	specimens	19.5 mm.–30.9 mm. (24.3 mm.–36.5 mm.)
July	13	5	specimens	18.7 mm.–34.0 mm. (23.4 mm.–41.7 mm.)
	15	1	specimen	39.7 mm. (48.5 mm.)
	19	1	specimen	16.4 mm. (20.4 mm.)

[3] Part of long-range ecological studies by the Entomological Research Center, Florida State Board of Health, of factors governing abundance of salt-marsh dipterans.

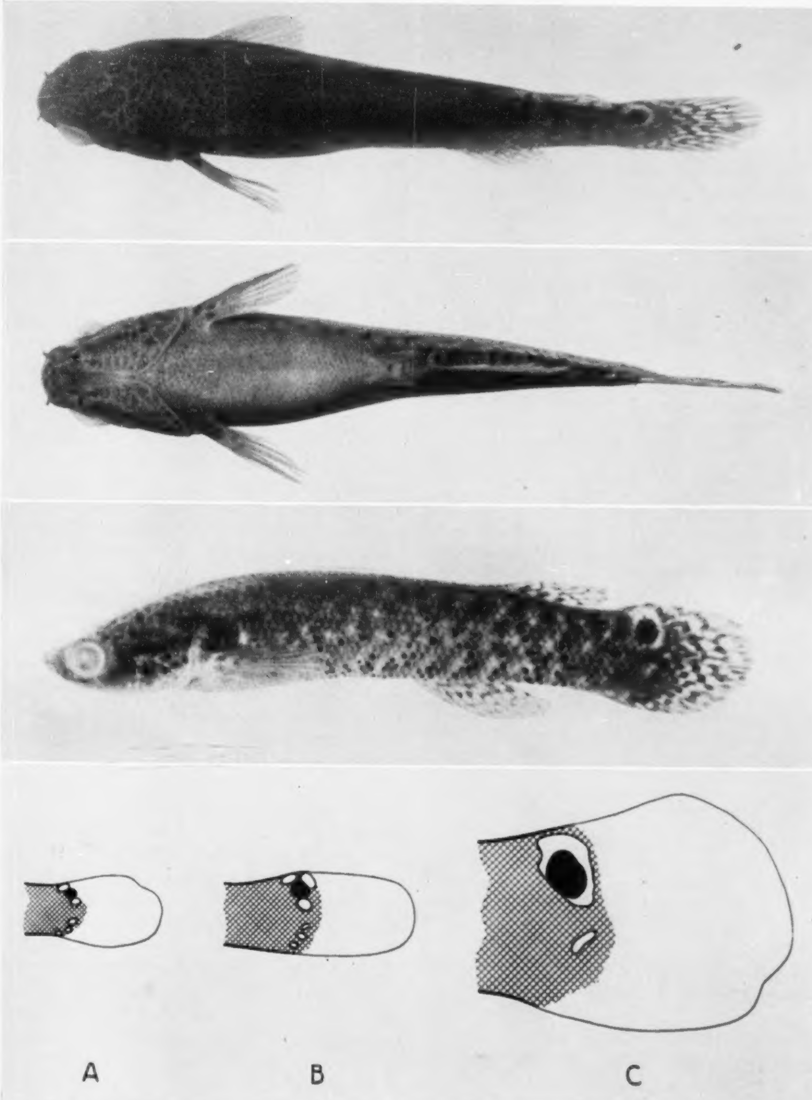

Plate I. *Above:* Dorsal, lateral, and ventral aspects of a specimen of *Rivulus marmoratus* Poey of 32.0 mm. standard length (39.8 mm. total length) collected July 13, 1955 by R. W. Harrington, Jr. and W. L. Bidlingmayer in St. Lucie Co., Florida (now USNM 174968). Photograph of lateral aspect provided through the courtesy of the United States National Museum, those of dorsal and ventral aspects, taken by Dr. E. T. Nielsen. *Below:* Semi-diagrammatic camera lucida drawings of caudal ocellus of *R. marmoratus* specimens of three lengths: A, 10.3 mm. (13.2 mm.); B, 15.3 mm. (19.6 mm.); C, 32.0 mm. (39.8 mm.).

Augus

Septer

Octob

The
in a
respec
the fl
dry a
collec
althou
water
and t
ous, r
under
giving
the d
from
per m
little
River
interv
ditch
mostl
Jacq.
topho
mang
botto
In or
ratus
devoi
A m
sites
has s
chang
ation
and
was f
a cat
carbo
pelle
the
destr
later
inroa
regio
Ri
other
I). I
put i
whic
Septe
its t

August	24	22	specimens	7.5 mm.–11.1 mm. (10.0 mm.–14.2 mm.)
September	17	1	specimen	23.4 mm. (29.0 mm.)
	18	1	specimen	33.6 mm. (41.4 mm.)
October	26	1	specimen	15.3 mm. (19.6 mm.)

The two September specimens were trapped in a dug sump and in a temporary pond, respectively, at about the farthest extent of the flood waters and over a bottom that was dry as late as mid-August. The rest of the collecting stations were all essentially alike although distributed along Indian River. The water was 1–2 feet deep, turbid to opacity, and the ditch bottoms were mostly treacherous, malodorous, marly muck, in some places underlain by a firm sandy substratum or giving way to a firmer bottom farther along the ditch. The range of salinity as known from the limited collection data was 21.6–32.3 per mille (mean, 28.1), and probably differed little from the nearby open waters of Indian River. Water temperatures during collecting intervals ranged from 30.0°C. to 35.5°C. The ditch segments collected in were shaded mostly by Black Mangrove (*Avicennia nitida* Jacq.) and were bordered by its pneumatophores; the Red Mangrove (*Rhizophora mangle* L.) was not uncommon; the ditch bottoms were strewn with mangrove leaves. In or near the regions where *Rivulus marmoratus* was taken, the ditches themselves were devoid of vegetation, including algal masses. A more explicit enumeration of collecting sites is unwarranted since much of the area has since undergone extensive hydrographic changes from dredging by dragline and alteration of banks through clearing of vegetation and filling by bulldozer. Much of the area was for a time almost devoid of fishes due to a catastrophic kill by a chlorinated hydrocarbon highly toxic to fishes, i.e. Dieldrin pellets were disseminated by air by one of the counties concerned, in an attempt to destroy sandflies (*Culicoides*). Nine months later a catastrophic cold wave made further inroads on the shallow-water fish fauna of the region.

Rivulus marmoratus was associated with 28 other fish species in varying numbers (Table I). It seemed always the last fish species to put in its appearance in reaction to rotenone, which was used in collecting all but the two September specimens. Despite its small size its tardy appearance at the water surface, usually within a foot of the bank, was instantly noticeable, owing to a unique darkness of coloration and a slow, snake-like bending of the body in the horizontal plane, said to be characteristic of the genus.

The specimen of July 15 and that of September 18, both females, were dissected. The former contained a crab, a snail, and an adult male strepsipteran; the latter, one adult female and five larvae of *Aëdes taeniorhynchus*, and three pupal heads of *Aëdes* mosquitoes, most probably of the same species.

TABLE I

OTHER FISH SPECIES COLLECTED WITH *Rivulus marmoratus* POEY

Frequency of Occurrence		Percentage of Total	
Rivulus marmoratus	8	*Fundulus g. grandis*	28
Gambusia a. holbrooki	7	*Mollienesia latipinna*	19
Mollienesia latipinna	7	*Fundulus c. confluentus*	18
Fundulus c. confluentus	5	*Gambusia a. holbrooki*	11
Fundulus g. grandis	5	*Dormitator maculatus*	4
Mugil curema	3	*Mugil curema*	3
Centropomus undecimalis	3	*Eucinostomus argenteus*	3
Cyprinodon v. variegatus	3	*Eugerres plumieri*	3
Eucinostomus argenteus	3	*Evorthodus lyricus*	2
Eugerres plumieri	3	*Rivulus marmoratus*	2
Evorthodus lyricus	3	*Cyprinodon v. variegatus*	2
Fundulus similis	2	*Centropomus undecimalis*	1
Dormitator maculatus	2	*Microgobius gulosus*	1
Gobiosoma robustum	2	*Lagodon rhomboides*	1
Strongylura marina	1	*Fundulus similis*	1
Syngnathus scovelli	1	*Syngnathus scovelli*	1
Lucania parva	1	*Mugil cephalus*	<1
Mugil cephalus	1	*Leiostomus xanthurus*	<1
Menidia beryllina	1	*Pogonias chromis*	<1
Lutjanus griseus	1	*Gobiosoma robustum*	<1
Leiostomus xanthurus	1	*Lutjanus griseus*	<1
Pogonias chromis	1	*Archosargus probatocephalus*	<1
Lagodon rhomboides	1		
Archosargus probatocephalus	1	*Eleotris pisonis*	<1
		Strongylura marina	<1
Eleotris pisonis	1	*Lucania parva*	<1
Microgobius gulosus	1	*Menidia beryllina*	<1
Gobiosoma bosci	1	*Gobiosoma bosci*	<1
Achirus lineatus	1	*Achirus lineatus*	<1

LITERATURE CITED

FOWLER, HENRY W. 1928. Fishes from Florida and the West Indies. *Proc. Acad. Nat. Sci. Philad., 80: 451–473.*

GARMAN, SAMUEL. 1895. The cyprinodonts. *Mem. Mus. Comp. Zool., 19(1): 1–179, pls. 1–12.*

JORDAN, DAVID STARR. 1887. A preliminary list of the fishes of the West Indies. *Proc. U. S. Nat. Mus., 9: 544–608.*

JORDAN, DAVID STARR, AND BARTON WARREN EVERMANN. 1896–1900. The fishes of North and Middle America. *U. S. Nat. Mus. Bull. 47 (4 pts.): 1–3313, pls. 1–392.*

JORDAN, DAVID STARR, BARTON WARREN EVERMANN AND HOWARD WALTON CLARK. 1930. Check

list of the fishes and fishlike vertebrates of North and Middle America north of the northern boundary of Venezuela and Columbia. *Rept. U. S. Comm. Fish. for 1928, pt. 2: i–iv, 1–670.*

MYERS, GEORGE S. 1927. An analysis of the genera of neotropical killifishes allied to *Rivulus. Ann. Mag. Nat. Hist. (ser. 9) 19: 115–129.*

POEY, FELIPE. 1880. Revisio piscium cubensium. *An. Soc. Exp. Hist. Nat., 9: 243–261 (1–19).*

REGAN, C. TATE. 1912. A revision of the poeciliid fishes of the genera *Rivulus, Pterolebias* and *Cynolebias. Ann. Mag. Nat. Hist. (ser. 8) 10: 494–508.*

RIVAS, LUIS RENÉ. 1944. Contributions to the study of the poeciliid fishes of Cuba. I. Descriptions of six new species of the subfamily Gambusiinae. *Proc. New England Zool. Club, 23: 41–53.*

———. 1945. The discovery and redescription of the types of *Rivulus marmoratus* Poey, a cyprinodont fish from Cuba. *J. Wash. Acad. Sci., 35 (3): 95–97.*

ENTOMOLOGICAL RESEARCH CENTER, FLORIDA STATE BOARD OF HEALTH, VERO BEACH, AND UNIVERSITY OF MIAMI, CORAL GABLES, FLORIDA.

Ichthyological Notes

OFFSHORE SPAWNING OF THE STRIPED MULLET, *MUGIL CEPHALUS*, IN THE GULF OF MEXICO.—The biology of the common or striped mullet, *Mugil cephalus* Linnaeus, has been the subject of numerous investigations, yet the locations of spawning grounds remain controversial. According to Higgins (1927, Rept. U. S. Comm. Fish., Bur. Fish. Doc. 1029: 624–627), Hildebrand and Schroeder (1927, Bull. U. S. Bur. Fish., 43(1): 192–196), Breder (1940, COPEIA (2): 138–139), Gunter (1945, Publ. Inst. Mar. Sci. Texas, 1(1): 51–52), and Taylor, *et al* (1951, Survey Mar. Fish. No. Carolina: 115) mullet spawn either inshore or within a few miles of the coast. Broadhead (1953, Fla. State Bd. Conserv., Tech. Ser. (7): 21) stated that indirect evidence, based on reports of commercial fishermen, indicates that spawning occurs in the Gulf, probably 5 to 20 miles offshore. Dekhnik (1953, Daklady Akademia Nauk, USSR; 93(1): 201–204) concluded that spawning of Black Sea mullet takes place chiefly near the coast, although some eggs of the species were found in plankton tows made far offshore.

For the past three years one of the projects of the Gulf Fishery Investigations has been a continuing study of the biology of East Lagoon, a narrow body of water slightly more than one mile long, in the northeastern end of Galveston Island, Texas. Waters of the lagoon are governed chiefly by tidal exchange via its opening into Bolivar Roads approximately three miles from the Gulf. Included in the information obtained during this study are pertinent observations on striped mullet. Large concentrations of roe mullet were observed frequently around the mouth of the lagoon from late October to mid-November. Although numerous schools of post-larval *M. cephalus*, 25–30 mm. in total length, appeared regularly by mid-December, and often were taken in the nets, periodic plankton collections made in the area never have yielded fertilized eggs or early larvae. This suggests that spawning takes place beyond the range of tides and currents moving in and out of Bolivar Roads. In partial support of this suggestion, the dense schools of roe mullet disappeared suddenly from the vicinity of the lagoon and Galveston beaches for about 10 days in late November, 1956. Upon reappearing in scattered small schools, the fish were found to be spent. This occurrence agrees closely with the repeated observations of Florida commercial fishermen reported by Broadhead (*op. cit.*).

The presence of fertilized eggs and/or early larvae coupled with observations of suspected spawning activities should be undeniable proof that spawning has occurred. These conditions were met during a recent tuna long-lining cruise (December 3–13, 1956) of the U. S. Fish and Wildlife Service M/V OREGON in the north central Gulf of Mexico. The general area occupied was over the continental slope in depths from 500 to 900 fathoms, and 40–50 miles southeast of the Mississippi River Delta.

Shortly after midnight on December 11, the OREGON was drifting in 755 fathoms of water at approximately 28°20′ N. Lat., 88°45′ W. Long. While engaged in dip-netting over the side of the slowly drifting ship, we were surprised to see a compact school of approximately 200 striped mullet appear beneath our night-light. The fish were large adults and some were thought to be females because of their distended abdomens. Dip-net captures later proved this to be correct. We could not determine whether or

not more than one school was involved, but mullet varying in number from about 50–250 circled the vessel every few minutes until just before dawn, swimming either at or within a few feet of the surface. As the sea was calm, we had a clear view of their activities.

From time to time as the schools came into sight, one or more groups of 3–6 fish would leave the school and swim around close to the surface in an erratic manner. Their subsequent behavior resembled that described by Breder (*op. cit.*); apparently spawning was taking place. As our field of visibility was limited to the illuminated area provided by the floodlight (about 30 feet out from and 50 feet along the side of the OREGON), a single group was seldom under observation for more than a minute. The actions described, therefore, are a composite of the behavior patterns of the 25 to 30 groups witnessed throughout the period of observation. In a typical group, the males, noticeably smaller and more slender, maintained positions slightly behind what was ostensibly a female. Five or six times while they remained in view, one or more of the males would quickly move up beside or below the female, nudging and pressing against her abdomen with head and body. Often during this action the individuals thus engaged would quiver and cease swimming momentarily, sometimes rising to the surface. The unoccupied males swam rapidly back and forth in the immediate vicinity until they in turn behaved in a similar fashion. We did not observe any of the "tight" formations of spawning groups described by Breder (*op. cit.*). There was little of the splashing and "milling around" that characterized the spawning activities of the closely related species, the silver mullet, as described by Anderson (1957, U. S. Fish and Wildlife Service, Fish. Bull. 119(57): 397–414). There was no evidence of milt or eggs in the water, but this could have been due to the drifting of the ship and the relatively small numbers of active spawners.

Seven fish were dip-netted from three of the spawning groups and identified as *Mugil cephalus*. Three were females with fork lengths of 285 mm., 290 mm., and 258 mm. The males measured 258 mm., 257 mm. (2), and 240 mm. Eggs could be extruded from the females with the slightest abdominal pressure and milt ran freely from the males.

In an attempt at fertilization, we placed milt and eggs from a captured male and female in an 8-quart plastic bucket containing sea water. The experiment was not successful. However, we later learned that Anderson (*op. cit.*) also failed in fertilization attempts with silver mullet using an aquarium of several gallons capacity, but succeeded when he used small culture jars. The reason(s) for this difference in results is unknown.

A series of eight sub-surface plankton tows with a #1 monel mesh net was made during long-line operations. The net, with a 15-inch diameter opening, was towed at an average speed of 4 knots. On numerous occasions throughout this period we observed thousands of little silvery fish in the area, swimming near the surface in small, closely packed schools. The plankton samples, sorted at the Galveston laboratory, yielded over 2,000 of these, or strikingly similar fish, varying in total length from 4 mm. to 25 mm. The larger specimens (20 mm. and over) were identified as striped mullet by careful comparison with known post-larvae of the species previously taken in local collections. A developmental series down to 9 mm. in length, tentatively identified as *M. cephalus*, was obtained by working backwards through successively smaller sizes. For possible confirmation, 30 specimens of varying sizes were picked indiscriminately out of more than 2,000 in the plankton collection and forwarded to W. W. Anderson at the Brunswick laboratory. He identified 20 of these specimens as *Mugil* species, not *Mugil curema*. In qualifying his identification Anderson pointed out that the fantail mullet, *Mugil trichodon* Poey, also present in the Gulf, has the same anal fin-ray count as *M. cephalus*. As the very young of the fantail mullet never have been described, larval forms of the two species could have been confused. However, as fantail mullet occur in the northern Gulf only as occasional strays, and as spawning activities observed in the early morning hours of December 11 were unquestionably those of striped mullet, such a possibility is extremely remote.

Additional evidence that we had witnessed actual spawning of *M. cephalus* was the presence of several hundred fertilized eggs of the species in the plankton collection. The eggs, in early stages of development, were identified by comparing them, microscopically, with those stripped from the captured females.

While by no means excluding the possibility of inshore spawning, the foregoing observations and plankton collection results, including size range of the larvae and post larvae, should establish conclusively that spawning of striped mullet does occur offshore in relatively deep water and for a period of at least several weeks.

Other offshore observations of *Mugil cephalus* are of possible significance and are offered for consideration. No fish were captured, but the

observations were made by fisherman who had fished commercially for mullet for many years, and all were positive in their identification.

On November 27, 1950, the OREGON was at anchor off the Texas coast 30 miles southeast of the Aransas Pass jetties in 30 fathoms of water. Personnel aboard the vessel observed large striped mullet in schools of about 50–200 at various times from 0340 to 1252 hours. That afternoon, while the vessel was underway, similar schools were sighted on four occasions between 1336 and 1430 hours, from 27°30′ N, 96°29′ W to 27°23′ N, 96°23′ W. Depths ranged from 42 to 59 fathoms. Unfortunately, actions of the mullet were not noted.

William T. Cothrun, a commercial fisherman of Sabine Pass, Texas, reported, in a personal interview, that he had encountered immense shoals of striped mullet in late November, 1950, some 65 miles south of Mobile, Alabama, in 20–25 fathoms of water. Mr. Cothrun was aboard the P-83, an oil company motor vessel. According to his account, the ship steamed through the shoals for several hours. The mullet were swimming slowly in an easterly direction, frequently with their heads out of water, at which times "smacking" noises were audible.

The authors are indebted and grateful to Mr. Anderson for his kind assistance in the preparation of this paper.—EDGAR L. ARNOLD, JR. *U. S. Fish and Wildlife Service, Galveston, Texas,* AND JOHN R. THOMPSON, *U. S. Fish and Wildlife Service, Pascagoula, Mississippi.*

RECORDS OF THE FLOUNDER, *CHASCANOPSETTA LUGUBRIS* ALCOCK, FROM THE WESTERN ATLANTIC.—Norman (1934, A systematic monograph of the flatfishes (Heterosomata), Vol. 1, British Mus. Nat. Hist., London.) recognized two species of *Chascanopsetta*: *C. lugubris* recorded off the southeast coast of Africa, Gulf of Manar, Bay of Bengal, and off Japan in deep water; *C. prorigera* Gilbert recorded from waters near the Hawaiian Islands.

Brunn (1937, Vidensk. Medd. Naturh. Foren. Kjøb., 101: 125–136) extended the range of *C. lugubris* to the eastern Atlantic (8° 26′N, 15° 11′W) after studying a completely metamorphosed specimen collected by the DANA off the west coast of Africa, and to the western Atlantic (26° 16′N, 63° 05′W) based on a larval form described but undetermined by Kyle (1913, Rep. Danish Oceanogr. Exped. 1908–10, Mediterranean Adj. Seas, Vol. 2, A. 1. Copenhagen). Brunn's determination of the larval form is based on the facts that the characters of no other flounder then known from the Atlantic fitted the meristic data for that larva, and on his new record of *Chascanopsetta* from the eastern Atlantic. Because of morphometric differences between the specimen examined by Brunn (1937, *op. cit.*) and the species description given by Norman (1934, *op. cit.*: 250–251), Brunn proposed a subspecific designation for the Atlantic material and assigned the name *C. lugubris danae*.

TABLE I

LOCALITY RECORDS FOR *Chascanopsetta lugubris* IN THE WESTERN ATLANTIC

Station No.	Cat. No.	Latitude	Longitude	Date	Depth (fathoms)	Gear
Oregon—1537	UMML 49: 701	24° 29′N	83° 27′W	6–15–56	212	72 ft. balloon trawl
Oregon—1541	CNHM 64234	24° 28′N	83° 29′W	6–15–56	220	72 ft. balloon trawl
Oregon—1543	UNC 1850	24° 28′N	83° 28′W	6–16–56	210	72 ft. balloon trawl
Combat— 23	UNC 1342	29° 55′N	80° 12′W	8–7–56	185–190	40 ft. flat trawl
Combat— 229	UNC 1341	27° 39′N	79° 50′W	1–31–57	180	40 ft. flat trawl
Combat— 271	UNC 1340	24° 17′N	82° 25′W	3–12–57	200	80 ft. balloon trawl
Combat— 467	UNC 1849	28° 36′N	79° 54′W	7–30–57	220	40 ft. flat trawl

During exploratory fishing off the southeastern coast of the United States and the Gulf of Mexico, the U. S. Fish and Wildlife Service vessels OREGON and COMBAT collected the first completely metamorphosed stages of *Chascanopsetta* from the western Atlantic. Examination of this material shows that two species are represented. One of these, assignable to *C. lugubris* Alcock, is the subject for this paper. The other species (represented by three specimens) is apparently undescribed and awaits further material for study.

Seven *Chascanopsetta lugubris* have been examined from the OREGON and COMBAT materials (Table I). The specimens are in the University of North Carolina Research Fish Collection (UNC 1340, 1341, 1342, 1849, 1850), the Collection of the Marine Laboratory, University of Miami (UMML 49: 701), and the Chicago Natural History Museum (CNHM 64234).

The western Atlantic material is compared

(Table II) with Brunn's specimen (1937, *op. cit.*), and with the description given by Norman (1934, *op. cit.*: 250–251). Due to apparent wide variation in morphometric data it is difficult to substantiate Brunn's belief that the Atlantic form of *lugubris* represents a new subspecies. Such designation should await the study of additional material.

The larval form of *Chascanopsetta* upon which Brunn (1937, *op. cit.*) extended the range of *lugubris* to the western Atlantic does not appear to be that of *lugubris*. This observation is based on the known anal ray counts for metamorphosed individuals from the Atlantic. In Table II *lugubris*, as defined by Norman (*op. cit.*: 250–251), has a range of 77–85 anal rays. The western Atlantic material has an anal ray count of 76–81. The anal ray count for the larval form identified by Brunn (1937, *op. cit.*) is 88. It is unlikely that such a difference in anal ray counts would exist between larval and metamorphosed forms. It is possible that the larva is an early stage of the apparently undescribed species of *Chascanopsetta* (UNC 1343, 1851) now known to occur in the western Atlantic, and which has an anal ray count of 87–90 (3 specimens).

We wish to thank Harvey Bullis of the U. S. Fish and Wildlife Service for making available five of the specimens examined. Also, we extend our appreciation to C. Richard Robins of the University of Miami and to Loren P. Woods of the Chicago Natural History Museum for the loan of specimens under their care.—EARL E. DEUBLER, JR., *University of North Carolina Institute of Fisheries Research, Morehead City, North Carolina,* AND WARREN F. RATHJEN, *U.S. Fish and Wildlife Service, Jacksonville, Florida.*

A NOMENCLATURAL DISCUSSION OF THE ARGENTINID FISH *MICROSTOMA MICROSTOMA* (RISSO) WITH NEW RECORDS FROM THE EASTERN PACIFIC, AND COMMENTS ON THE POSSIBLE IDENTITY OF THE GENUS HALAPHYA GÜNTHER.—Risso (1810, Ichthy. Nice, p. 356) described *Gasteropelecus microstoma* from Nice, France. (Certain authors have persisted in using as a generic name the colloquial term "serpe" which Risso appended to his description. The problem has been discussed by Bolin (1939, Stanford Ichthy. Bull. 1: 128) whom I follow.) He stated that the species possesses a curved lateral line; an anterior rayed dorsal fin situated in the center of the back; and a second dorsal fin, also rayed. None of these features are characteristic of the species recognized today as *Microstoma microstoma*, although the remainder of the description fits fairly well.

Cuvier (1817, Regne Anim., 2: 184) proposed the genus *Microstoma* for "la Serpe microstome" or *Gasteropelecus microstoma* Risso. Cuvier stated "une seule dorsale peu en arrière des ventrales." His description was undoubtedly based on a specimen which Valenciennes (1846, Hist. Nat. Poissons, 18: 266) stated was sent by Risso to the Paris Museum in about 1812 and which was labeled by Risso as *Gasteropelecus microstoma.*

In Risso's (1826, Hist. Nat. Europe Merid., 3: 474) description of *Microstoma rotundata* he included references to his original description of *Gasteropelecus microstoma* and also to Cuvier's description of *Microstoma*. Risso's (1826, *op. cit.*) description stated that the lateral line is straight,

TABLE II

COMPARISON OF THE WESTERN ATLANTIC FORM OF *C. lugubris* WITH MEASUREMENTS GIVEN BY NORMAN (1934) AND BRUNN (1937)

	Indo-Pacific (Norman) Range	Eastern Atlantic (Brunn)	Western Atlantic Range
Standard length, mm.	142–245	147	140–284
Ratios			
S.L.: Body depth	3¼–nearly 4	3⅓	2.7–3.3
S.L.: Head length	4–5¼	5½	4.2–4.9
Head length: Diameter upper eye	3⅔–4	3 9/10	3.8–4.4
Diameter upper eye: Interorbital width	3–5	2⅜	2.4–3.7
Head length: Maxillary length	1¼–1⅖	1⅓	1.3–1.4
Straight lateral line: Lateral line arch	5–5¾	6 9/10	5.2–6.9
Head length: Left pectoral length	1¾–2⅛	1⅜	1.7–2.1
Dorsal rays	114–122	115	114–118
Anal rays	77–85	81	76–81
Left pectoral rays	14–17	17	14–16

the first dorsal is situated slightly behind the ventrals, the second dorsal is barely visible, and the scales extend onto the caudal fin. His figure (36) of *Microstoma* could be interpreted as a poor representation of *Nansenia*, and has a straight lateral line, the rayed dorsal fin originating slightly before the ventral fins, a dorsal adipose fin present over the anal fin base, and the scales not extending onto the caudal fin base.

Valenciennes (*ibid.*) discussed the problem and proposed a new name, *Microstoma argenteum*, based on Risso's specimen of *Gasteropelecus microstoma* as well as additional material sent to the Paris museum by other correspondents. Valenciennes' (*ibid.*, pl. 544) figure of *Microstoma argenteum* showed a straight lateral line, the dorsal originating slightly behind the ventrals, an adipose fin absent, and the scales extending out on the caudal fin base. Concerning Risso's

figure of *Microstoma rotundata*, Valenciennes stated, "On dirait que l'auteur a mis la tête d'un individu de ce genre sur un corps de quelque saurus."

Schmidt (1918, Rep. Danish Oceanogr. Exp. 1908–1910, 2: (4), (A 5): 22) discussed the problem and suggested that Risso may have based his description of *Gasteropelecus microstoma* on a mixed collection of *Microstoma argenteum* and *Nansenia oblita*, which is also known to occur at Nice. Other authors have also commented on the problem.

Thus it seems obvious that Risso has based his description of *Gasteropelecus microstoma* on two species, one of which is most certainly the species currently recognized as *Microstoma microstoma*, while the other may be a species of *Nansenia*. Fortunately, the specimen which Risso labeled as *Gasteropelecus microstoma* and sent to the Museum National d'Histoire Naturelle in Paris is extant. The specimen is undoubtedly part of Risso's type material since the original description stated the fish was deux décimètres in length and Bertin (1940, Bull. Mus. Hist. Nat. Paris, 12: 308) reported that the specimen now in Paris is 200 mm. in length. Bertin (*ibid.*) listed the specimen as a paratype of *Gasteropelecus microstoma*; however, since no holotype was ever designated, the specimen is actually a syntype. I hereby designate this specimen (Paris Museum no. 3668) as the lectotype of *Microstoma microstoma* (Risso). This action serves to positively identify the name *Gasteropelecus microstoma* Risso, with specimens recognized under any of the names listed in the synonymy of *Microstoma microstoma* (Risso).

This species was long known from only the Mediterranean and tropical eastern Atlantic. Grey (1956, Copeia: 242) recently reported on a specimen from the Gulf of Mexico. I have had the opportunity of examining five examples ranging from 13.5 to 44.5 mm. in standard length, which were collected in the eastern Pacific at localities between Monterey Bay, California, and the west coast of central Baja California. The specimens are deposited in the collections of the Stanford Natural History Museum. The data are as follows: SU 49800 (1), SU 49801 (1), "Tage" Sts. 264B and 258B respectively, 36° 42′ N, 122° 2′ W, in Monterey Bay, California, between 1297 meters and the surface, collected at midday; SU 49797 (1), 33° 30′ 06″ N, 118° 18′ 40″ W, near Santa Catalina Island, California, between 1000 meters and the surface; SU 49798 (1), U.S. Fish and Wildlife Service, South Pacific Fishery Investigations St. Y-38 100.65, 30° 31′ N, 119° 06′ W, off the west coast of central Baja California (alizarin specimen); SU 49799 (1), S.P.F.I. St. C-40 110.60, 28° 56′ N, 117° 39′ W off the west coast of Central Baja California.

The genus *Halaphya* was proposed by Günther in 1889 (Rept. Sci. Res. H.M.S. "Challenger," 31, (2): 38) for several small, nondescript fish collected by the "Challenger" from the surface of the Tasman Sea. Günther questioningly suggested affinities with *Microstoma*. Jordan (1923, Stanford Univ. Publ., Univ. Ser., Biol. Sci., 2: 125) listed *Halaphya* in the family Microstomidae. Hubbs (1953, Copeia: 96) suggested that *Halaphya* might belong in the synonymy of *Microstoma*.

Günther's figure of *Halaphya* (*ibid.*, pl. 6, fig. c) agrees with *Microstoma* in having an elongate body, small mouth, dorsal fin inserted behind the ventral fins, and no dorsal adipose fin. It differs from *Microstoma*, however, in having a smaller eye, shorter pectoral fin, more compressed body, longer anal fin base, caudal fin emarginate rather than forked, and in having a ventral adipose fin. The possibility arises that *Halaphya* may be an aberrant or larval galaxiid, retropinnid, or aplochitonid, but too little is known of the early stages of these fish for reliable comparisons. An especially striking similarity between *Halaphya* and *Retropinna* is the presence in both of an elongate, ventral adipose fin.

I am endebted to Professor G. S. Myers and Mr. W. I. Follett for discussions of the nomenclature. Professor Carl L. Hubbs first called the problem to my attention. I also thank Professors Rolf Bolin and Jay Savage and Dr. E. H. Ahlstrom for allowing me to report on their specimens and Dr. Ernest Lachner for reading the manuscript and discussing it with me.—Daniel M. Cohen, *Department of Biology, University of Florida, Gainesville, Florida.*

MODIFICATION OF MERISTIC CHARACTERS BY LIGHT DURATION IN KOKANEE, *ONCORHYNCHUS NERKA*.—Latitudinal clines in meristic characters occur commonly in fishes; many unrelated species show a tendency towards higher meristic counts, particularly of vertebrae, at the northern ends of their ranges. These clines may be either the phenotypic result of environmental gradients, or they may be genotypic. If genotypic, they are presumably still attributable to selection associated with some environmental gradient (Hubbs, 1928, Anat. Rec. 41: 49). The hypothesis that latitudinal clines are phenotypically produced by lower temperature towards the pole is not well supported by laboratory experiments, which in the majority of cases have shown a V-shaped relationship between temperature and vertebral count. More-

over, the northward increase in vertebrae is sometimes more regular than might be anticipated were it solely dependent on temperature, subject to much local variation.

Possible sources of meristic variation which alter with latitude more regularly than does temperature, are those factors associated with light (its quality, intensity, and duration). Light intensity has been shown capable of controlling vertebral count (McHugh, 1954, COPEIA (1): 23–25). The following experiment was conducted to determine whether light duration might also alter meristic counts.

Artificially fertilized eggs of kokanee, a landlocked form of *Oncorhynchus nerka* (Walbaum), were obtained from Premier Lake, east Kootenay district, British Columbia, on 10 October 1956. These (the resultant of mixture of eggs and sperms from several adults of each sex) were flown to the Institute of Fisheries at the University of British Columbia in Vancouver. They were there divided into two lots each of about 1200 eggs. These were reared in trays standing in troughs of running water, the temperature of which dropped gradually during the course of the experiment from 13.0°C. to 5.1°C. Each tray was covered by a light hood so that the only illumination was from a 7½ watt frosted light bulb suspended inside the hood 18 cm. above the water surface. Eggs lay in a single layer 12 cm. below the water. When the light bulb was on, the surface of the water received illumination ranging from 6 foot candles directly under the bulb, to 3.5 foot candles in line with the edges of the tray. The only environmental difference between the two lots of eggs throughout the experiment was the duration of light exposure, which was controlled by electrically operated time switches. One egg lot was subjected to 8 hours of light and 16 hours darkness each day, the other to 16 hours of light and 8 hours darkness.

The average time to hatching was about 70 days; those given 16-hour light exposure tended to hatch somewhat sooner than those given 8 hours. After 82 days, when all surviving eggs had hatched, the two lots of fish were transferred to troughs subjected to subdued natural light, and were held for an additional 45 days before preservation.

Survival was higher in the 8-hour lot than in the 16-hour lot. A total of 470 fish survived in the 8-hour lot (35 percent of the original number of eggs), and only 211 in the 16-hour lot (18 percent of the original number). From each lot of survivors, about 120 fish without marked abnormalities were cleared in KOH and glycerin and stained with alizarin dye. Each fish was then measured (total length) and the number of caudal vertebrae and of anal fin rays was counted. Caudal vertebral count started at the first vertebra having a visible haemal spine. The urostyle was not included in the count. In most specimens vertebrae could be counted easily as the neural spines were ossified. Smaller individuals in each lot tended to be only slightly ossified; in these, myotomes rather than spines were used as an indication of segmentation. Anal ray counts did not include the anterior very short and slender one or two rays. The last two rays, which in adults arise from a common basal, were counted as one.

Table I shows that 8-hour light exposure produced significantly higher caudal vertebral and anal fin ray counts than did 16-hour exposure ($p < 0.01$). It was moreover observed that although all fish studied had been preserved at the same time, those subject to shorter light exposure had on the average reached a more advanced state of development, as indicated by greater total length, smaller yolk sac, and more complete ossification.

Although fish in the 8-hour lot were significantly longer ($p < 0.01$) than those in the 16-hour lot (total length $19.27 \pm .074$ mm. in the former, $18.96 \pm .072$ in the latter) no correlation was apparent between caudal vertebral count and length within each lot. From this, and from the appearance of the posterior region of the specimens, it is concluded that the fish had definitely reached their final caudal vertebral count, and that light-duration had a significant effect on this definitive count.

Because the ends of the anal fin ray series were less well defined than those of the caudal vertebral series, there exists the possibility that the observed difference in ray count might be attributable to preservation of fish before they had achieved their definitive counts, coupled with the observed retardation of development of the 16-hour lot. Indeed, within each lot, a significant tendency was observed for the larger fish to have higher ray counts. However, that the higher ray count of 8-hour fish is not attributable solely to size difference between the two lots is suggested by the fact that, when comparisons were made only between comparable size groups, 8-hour fish still consistently showed higher counts than 16-hour fish. (This tendency for fin ray count to be associated with size within single lots of experimentally reared fish has been observed previously by the author in *Gasterosteus aculeatus* (unpublished) which were reared to a much later stage of development. In the latter experiments, as in those presently reported, no

correlation was found between vertebral count and length within lots.)

While it was shown that longer light exposure produced lower anal ray count in fish of the same size group, there still remains the possibility that these fish, despite their length, might nevertheless be less advanced in ossification of rays. Their ray count might conceivably have overtaken that of the lot exposed to shorter light had all fish been reared to greater size.

This experiment demonstrates that certainly the number of caudal vertebrae and probably the number of anal fin rays of kokanee are subject to alteration by the duration of light exposure during their early development. No immediate applicability to meristic variation of wild kokanee is implied, because no clinal variation has been demonstrated, and because kokanee eggs buried in gravel are probably never exposed to a light intensity comparable to that used experimentally. Indeed, the 16-hour exposure may have produced a deleterious effect as suggested by the slower development, greater proportion of abnormalities, and higher mortality. The significance of the experiment is rather the demonstration that day-length can, under some circumstances, alter the number of parts in fish. The applicability of this finding to clines in wild populations warrants further study.

TABLE I

EFFECT OF LIGHT DURATION ON KOKANEE MERISTIC COUNTS

Light Duration	Caudal Vertebrae					
	23	24	25	26	27	Mean
8-hour	—	2	52	48	9	25.57
16-hour	1	32	61	22	—	24.90
	Anal Fin Rays					
	11	12	13	14	15	Mean
8-hour	4	13	51	46	2	13.25
16-hour	17	32	48	22	—	12.63

Assistance of members of the British Columbia Game Commission is gratefully acknowledged, particularly J. W. Cartwright who cleared and counted the specimens, and F. P. Maher who obtained and shipped the eggs. D. E. McAllister, T. G. Northcote and E. J. Crossman also contributed to the study. Financial assistance was provided by the National Research Council of Canada.—C. C. LINDSEY, *Institute of Fisheries, University of British Columbia, Vancouver, Canada.*

A METHOD OF ANALYSIS OF THE SWIMMING OF FISH.—Primarily through the work of Gray (1933, J. Exp. Biol. 10: 88; *ibid.* 10: 386; *ibid.* 10: 391) we have come to understand the geometry of the propulsive thrust generated by a swimming fish. Given an understanding of the nature of the thrust developed, it becomes of interest to see how this thrust actually is applied during normal swimming activities of the animal.

The swimming of fish may be analyzed graphically from cinematographic records. This analysis could prove to be useful in behavioral, ecological and management studies. The procedure is simple.

The fish to be studied are photographed from above as they swim over a background grid, or in the neighborhood of fixed reference points. The film should be exposed at high speed to stop the action as completely as possible. Commonly ciné-cameras allow the exposure of 64 frames per second, a speed which is generally sufficient.

A specimen which has performed satisfactorily for the camera is followed on the developed film for as many frames as possible. This may be done by enlarging and mounting positive prints of sequences of frames from the film or by projecting the film and tracing from individual frames the specimen and its reference points. On this record one first determines the number of body waves formed by the fish as it swam across the field of exposure. This is best done by marking the crest of each wave in each of the frames in which it appears. The waves of course overlap contralaterally. Fig. 1 shows a sample record with wave crests marked. This specimen provided part of the data of Fig. 2.

The rate of forward progression can be plotted when the number of body waves involved in a given sequence is known. Forward progression is related to the body waves which have provided the propulsive thrust. Let us assume the fish was photographed moving over a grid of standard units. If the first body wave taken into account lasted through five frames and during these five frames the fish moved ahead eight units of the grid, then the amount of progression may be recorded as 8 units/5 frames. So, for each body wave one gets the rate of progression in units/frames.

To obtain relative data on the body wave, one follows a similar procedure. The first body wave, in our example above, covered five frames. The movement of the crest of this wave is followed

through the five frames and its displacement is measured in grid units from its point of origin as marked on the background. If the background is not a grid, the measurements must be made to some fixed point of reference a distance from the specimen. Then the body wave is made relative to the speed of progression by measuring its displacement posteriad from the most rostral point on the specimen and subtracting this quantity from the distance the fish progressed in the five frames being considered. The movement of the wave is recorded as units/frames also. The figure obtained may be positive, if the wave moved backward relative to the environment of the fish; it may be negative, if the wave moved ahead; it may be zero, if there is no apparent displacement of the crest of the wave. The positive value is given the backward moving wave because thrust is provided only if the wave moves backward faster than the fish moves forward (Breder, 1926, Zoologica 4: 159; Gray, 1933, J. Exp. Biol. 10: 88). The importance of this phenomenon will become apparent below, when the analysis of sample records is presented.

When these data have been obtained, they may be plotted as fractions, with, in each case, the number of frames forming the denominator, the units the specimen moved being the numerator. Quantities to be plotted are provided by dividing the number of units moved by the number of frames involved with any given wave. The quantity 'units/frame' may be given dimensions if the size of the background grid and the track speed of the film is known; e.g., 8 units/5 frames may correspond to 8 mm./.08 sec. (=10 cm./sec.), etc. From Fig. 2 it can be seen that separate lines are plotted for progression and for the movement of the body wave. The abscissa records the number of body waves involved; the ordinate marks the movement of the animal or of the body wave. A mean, struck by inspection between the plotted speed of progression and relative rate of the body wave, gives a qualitative picture of the force (thrust) produced by each wave.

By plotting the data obtained from the study of a number of specimens on the same ordinate scale the swimming characteristics of several individuals or of the same specimen at different speeds or under different conditions can be directly compared.

While the analysis that follows does not attempt it, it is possible to use data of this type quantitatively. By photographing the animals over a grid one may measure wave lengths, wave amplitudes, speeds of progression and, by means of more refined calculations, and additional measurements, amount of thrust developed during a given period.

Let us examine several specimens to compare performances and to see what sort of characteristics may be expected to appear in the charts. The specimens here examined are fingerling splake trout (F_1 *Salvelinus namaycush* × *S. fontinalis*) produced in the Province of Quebec and raised at the Jasper National Park Fish Hatchery, Alberta. The fish were photographed *en masse* in their rearing troughs in Jasper. The film was projected one frame at a time. Individual fish were chosen to be followed through several frames. From each frame the outline of the fish was carefully traced. Under the conditions obtaining during filming, the background grid failed to show upon the film. However, numerous fixed points of reference were available. By using these points the required measurements were made within reasonable limits of error. A grid etched on a sheet of stiff, transparent plastic greatly facilitated the taking of measurements from the tracings.

Fig. 1. Tracings, from successive frames of ciné film, showing contralateral waves moving back along the body of a specimen. Wave crests are marked by dots. The waves shown represent numbers 10–15 of Fig. 2

Part of this work was done while the author was a Summer Research Associate of the National Research Council of Canada (1956). Photographic equipment was supplied by the General Research Fund of the University of Alberta. The cooperation and assistance of the Director of the National Parks Branch and of Mr. W. C. Cable, Superintendent of the Jasper Park Fish Hatchery is gratefully acknowledged. I wish to thank also Drs. E. M. Nelson and G. E. Ball for critical help with the manuscript.

SPLAKE IIIc (Fig. 2).—Followed over a course of 59 frames, this specimen developed 19 body waves, i.e., 0.32 waves per frame. Individual waves lasted from five to nine frames.

In this example, the curve for the rate of pro-

gression shows two modes, i.e., twice the fish accelerated rather suddenly, and twice it decelerated.

The line plotted to indicate the relative rate of movement of the body wave is seen to vary about the zero mark. As the first acceleration began, the relative rate of the wave was positive, which is to say that the wave was moving posteriad relative to some fixed point in the environment. Therefore, thrust was being provided. This thrust was translated into acceleration. As the rate of progression increased, the relative rate of the body wave decreased to zero, then to a negative quantity. Simply, the movement forward of the fish was increasing more rapidly than the movement back of the body wave. When the speed forward of the animal equalled the speed backward of the wave, no thrust was provided, so deceleration followed. When the value of the relative rate of the body wave is negative, it means that inertia is carrying the fish forward at a speed greater than that at which the body waves are moving backward. The consequent deceleration is shown on the curve for rate of progress.

As the fish slowed down, the relative rate of the body wave increased, became positive again, thrust was provided, and the animal reaccelerated.

The middle line on the graph, the mean between rate of progression and the relative rate of the body wave gives an idea of the force exerted by the fish as it swims. In this particular case the force is seen to be more or less constant, despite the variation in the rate of progression and the relative rate of the body wave. Apparently the body wave was not changing greatly in form and a fairly steady thrust was being applied. This seems to indicate a difficulty in maintaining a constant speed at any given exertion of force, for force or thrust depends upon the form of the body wave and here, with a more or less constant wave, there is a repetitive variation in speed.

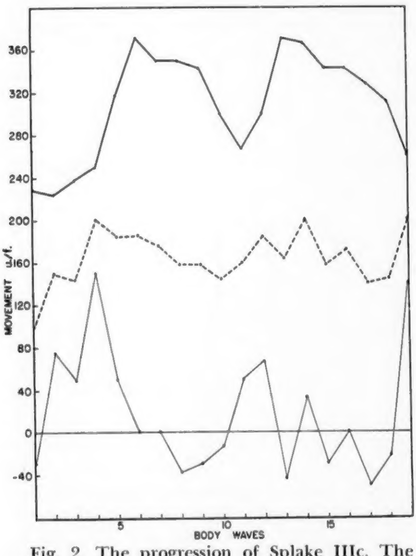

Fig. 2. The progression of Splake IIIc. The heavy line represents rate of progression; the fine line represents the relative rate of the body wave; the dashed line is the mean of the two, taken to be a qualitative representation of thrust; u./f. = units/frame.

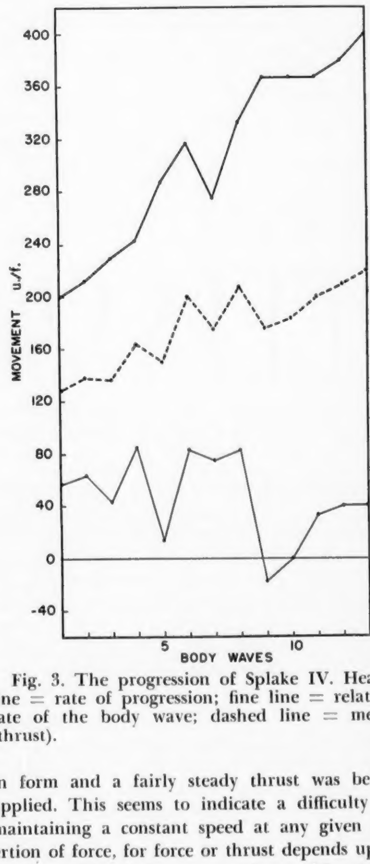

Fig. 3. The progression of Splake IV. Heavy line = rate of progression; fine line = relative rate of the body wave; dashed line = mean (thrust).

SPLAKE IV (Fig. 3).—This specimen was accelerating through the sequence in which it was followed. Thirteen body waves were formed in 39 frames, i.e., 0.33 body waves per frame. Individual waves lasted from four to eight frames.

The acceleration shown by the line for the

rate of progression in Fig. 3 is accompanied by a consistent increase in the thrust applied by the fish. This is shown by the trend upwards of the middle line of the graph. The relative rate of the body wave remained positive except at waves nine and ten. At that point, with the loss of thrust, the rate of progression slowed. Not until further thrust was applied to overcome the forces of resistance was acceleration resumed.

Splake IIIb (Fig. 4).—Here is a record characteristic of a fish gradually slowing down. In this case 14 body waves were formed in 61 frames. i.e., 0.23 body waves per frame. Individual waves lasted from five to thirteen frames.

The top line of Fig. 4 clearly shows the gradual deceleration of this specimen. The middle line shows a correlative consistent decline, indicating a falling off in the thrust produced by the swimming fish. The lowest line, showing the relative rate of the body wave, takes a more irregular course. The point of interest is the interpretation of this lowest line.

The initial spurt shown by the curve for the rate of progression was brought about by a momentary increase in thrust. The increased speed is mirrored by a decrease in the relative rate of the body wave. Following this for a few waves, the force exerted by the fish remained more or less constant. This was enough to cause a slight increase in the rate of progression and a decline in the relative rate of the wave. As the wave rate fell below zero, the rate of progression slowed. An extra thrust from wave seven failed to halt the slowdown. Apparently there was no continued reaction by the fish to the braking action of water resistance. An increasingly rapid deceleration occurred, with there being little movement of the body wave relative to the background. During this period (waves eight to eleven) the thrust, as shown by the middle line of Fig. 4, remained constant. It must be kept in mind that, since the line representing thrust is qualitative only, it is representing zero thrust at this time, for the relative rate of the body wave is zero. In other words, the height of the mean line above the base has signifiance only when related to the wave rate (cf. Figs. 2, 3, and 5).

In this specimen, the application of thrust by the animal (at wave 12) eventually lessened the rate of slowdown.

Splake II (Fig. 5).—This graph is a record of a fish travelling at high speed. Twenty-five body waves were recorded in 33 frames, i.e., 0.76 waves per frame. The waves recorded covered from two to four frames.

Again the irregularities inherent in the mode of locomotion of fishes are apparent. While the general trend of each of the plotted lines (rate of progression; force exerted; relative rate of the body wave) is straight or constant, in detail each line shows ups and downs as the fish reacts to the environment through which it is moving and as the fish puts forth, again and again, a maximum effort.

As is to be expected, the relative rate of the body wave mirrors the rate of progression. Perfect mirroring would of course result in a

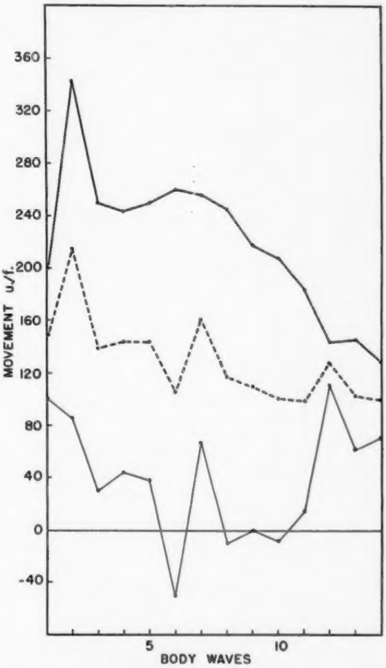

Fig. 4. The progression of Splake IIIb. Heavy line = rate of progression; fine line = relative rate of the body wave; dashed line = mean (thrust).

straight line for the mean (thrust). This, however, would indicate a loss of fine response by the fish to its environment. In general, an increase in speed is reflected in a decrease in the relative rate of the body wave until zero or a negative value is reached, at which time no thrust is provided. If the form of the body wave is unchanged, a decrease in speed must follow until there is once more a positive relative wave rate and an exertion of thrust. Thus in rapid swimming, at what appears to be a uniform rate, there is a repetitive approach to a high speed through maximum effort, followed by a falling

off of speed. This seems to be the normal mode of progression for fish.

Splake I (Fig. 6).—This shows a fish swimming at a fairly steady rate with a continuous production of thrust from its body waves. Eighteen body waves were formed in 48 frames, i.e., 0.38 waves per frame. The waves recorded lasted from four to seven frames each.

In this case again there was constant adjustment to conditions being made by the animal as it progressed. Also there was always a propulsive force being applied, i.e., never did the relative rate of the body wave become negative. For the first seven waves some rather wide fluctuations in thrust are seen. These kept the rate of progression more or less steady. An increased rate of body wave propagation through waves seven to twelve gave an acceleration of forward

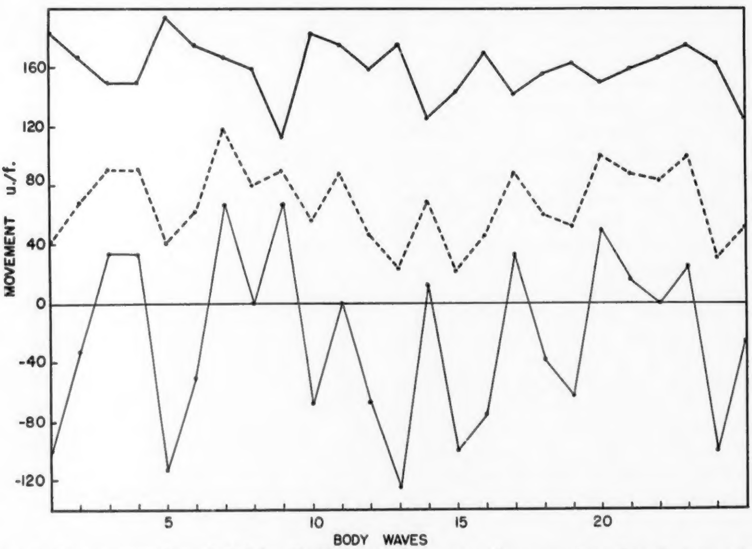

Fig. 5. The progression of Splake II. Heavy line = rate of progression; fine line = relative rate of the body wave; dashed line = mean (thrust).

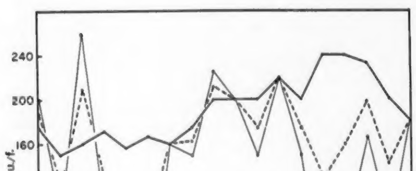

Fig. 6. The progression of Splake I. Heavy line = rate of progression; fine line = relative rate of the body wave; dashed line = mean (thrust).

movement. This was maintained to about wave 16 by a comparatively small, but still positive wave rate. Towards the end of the record, as the specimen slowed down, the relative rate of the body wave is seen to increase. Right across this record, the mean line, the qualitative indicator of thrust, varies considerably as the fish kept itself, as well as it could, in a desirable relationship to its environment.

Apparently, judging from the data presented in this paper, fish do not swim at a constant rate of speed, but their progression is uneven. There is always a slight amount of adjustment going on, as if the animal were responding most sensitively to its environment, e.g., to currents, obstacles, neighbors in a school. This unevenness will not be noticed if fish are being timed over a measured course to determine their speed, for such timing gives only the averaged thrust of many body waves. Moreover, the fine variations in progression which have been noted herein will

be missed by unaided visual observation, for they are small and occur extremely rapidly. Nevertheless, certain more gross variations in swimming speed are noticeable to the careful observer. The descriptive term 'darting' brings to mind the uneven movement we have all seen fish perform, a motion which need not involve a coming to rest between spurts. Furthermore, variations in frequency and amplitude of tail beat may be made out during careful observation of fast-swimming fish which apparently are travelling at constant speed.

The careful analyses of Gray (*op. cit.*) have shown that the body of a fish makes an angle of attack with its own path of motion. The greater this angle, the more thrust developed. Gray further showed that as speed increases, the angle of attack becomes smaller until it reaches a zero value at which point no thrust is developed. This point will be the limit of acceleration. I interpret this as meaning that a fish cannot swim full out at a constant speed, but that a repetitive acceleration and deceleration to and from maximum speed must be made. This is what has been seen above, particularly in Figs. 2 and 5. The more rapid the alternation of acceleration and deceleration, i.e., the shorter the period allowed for the latter, the more nearly constant will be the speed.

Probably, in a still environment, a fish can swim at a constant speed, at which speed the thrust developed equals the resistance of the water against progression, provided there is some variation in the wave form as it passes along the body of the fish (cf. Gray, 1933, J. Exp. Biol. 10, p. 389). However, this condition seems rarely to be fulfilled, chiefly because the environment is rarely still. The apparently erratic progression of a fish is necessary for the animal to maintain its spatial equilibrium, probably about all three axes.

In an environment that is rapidly and unpredictably changing because of currents, eddies, etc., it seems likely that the limit of acceleration will be reached at different absolute speeds under different conditions, so that a fish swimming with the exertion of less than full power nonetheless must alternately accelerate and decelerate in physical response to the environment.—J. R. NURSALL, *Department of Zoology, University of Alberta, Edmonton, Alberta.*

THE BREEDING BEHAVIOR OF THE SOUTHERN BLACKNOSE DACE, *RHINICHTHYS ATRATULUS OBTUSUS* AGASSIZ.—The breeding behavior of *Rhinichthys atratulus atratulus* (Hermann) was described by Traver (1929, Jour. Elisha Mitchell Sci. Soc. 45(1): 116–120) from Cascadilla Creek near Ithaca, New York, and that of *R. a. meleagris* Agassiz was reported by Raney (1940, Amer. Midl. Nat. 23(2): 399–403) from a tributary of Slippery Rock Creek near New Castle, Pennsylvania. The behavior of a third subspecies, *R. a. obtusus* Agassiz, was observed during the summer of 1956 at elevations of 1900–2200 feet in three tributaries of the Cheat River watershed, Tucker County, West Virginia, as follows: Big Run, one mile SW of W. Va. Hwy. Rt. 72 and two miles NE of Sully on June 27, 1956; Mill Run, ¾ mile NW of Elk on W. Va. Hwy. Rt. 72 on June 29, 1956; and Rattlesnake Run, five miles NE of Elkins on U. S. Forest Service Rt. 38 and two miles N of U. S. Rt. 33 on June 30, 1956.

These typical mountain brooks, with steep gradient, vary from two to three miles in length and are ten to fifteen feet wide. The beds are strewn with large round boulders, flat slab rock (only Mill Run), and lesser amounts of rubble, gravel and sand. Year around flow is maintained; for June it varied in all streams from five to fifteen cubic feet per second and was greatest in Big Run and lowest in Rattlesnake Run. *R. a. obtusus* spawned in Mill Run in water of 60° F., air 73° F., while in Big and Rattlesnake Runs the water was 64° F., air 69° F. Mill Run lies on a north facing slope, Rattlesnake Run and Big Run face west and south respectively.

In Mill Run from a point less than two feet away from the spawning site it was observed that the spawning of *obtusus* was consummated high in the water, whereas in subspecies *atratulus* and *meleagris* it occurs on the bottom. Table I compares subspecies as to breeding sites, behavior and color patterns. Raney (*op. cit.*: 401) noted that in spawning the female of *meleagris* was often thrust into a depression in the bottom. Traver (*op. cit.*: 117) found that *atratulus* spawned almost any place on the bottom and occasionally was thrust into the bottom sand or gravel.

Spawning pairs of *obtusus* assume a position such as noted by Traver (*op. cit.*: 118) for *atratulus* that is in midwaters of a shallow pool usually ten inches deep. In deeper pools, such as are found in Big Run, *obtusus*, when ready to spawn, shifts to a site where there is a depth of about ten inches. The spawning site is a roughly delineated area one to four feet square which never was found to occupy a riffle.

Upon sighting a ripe female, the male *obtusus* prods her about midway back on the side of her body. This forces her forward or "leads" her until the spawning site is reached. He does not swim back and forth before a female as Traver (*op. cit.*: 117) observed during the pre-spawning

behavior of *atratulus*. Once spawning has begun, the wiggling of the pair and the forward swimming attempts of the female to maintain a horizontal position tend to angle them up and forward in the water, rather than downward into the bottom gravel. Upon reaching the surface, the sexes separate and swim down to the original spawning depth and repeat the spawning act from two (usually) to five times, after which the female retires to the deeper water to rest. The male returns to a section of the breeding territory. A male may spawn with any female that he may meet or can "lead" to the spawning area. However, spawning frequently occurs without the "leading" ritual.

vigorously in the gravel and sand immediately below the spawning level. Aggressiveness was observed only when the hand of the observer covered the area where eggs had been deposited. The males nipped, side-swiped and banged their head against the hand in a frenzied effort to reach the freshly laid eggs, which become covered in the gravel and sand. However, if the hand, with spread fingers, was placed over the deposition zone, no aggressiveness was exhibited. The males then swam down between the fingers and continued eating eggs and rooting vigorously.

Neither male nor female *obtusus* attempt to excavate or fan the spawning site or otherwise

TABLE I

A COMPARISON OF THREE SUBSPECIES OF *Rhinichthys atratulus*[1]

Comparing Item	atratulus	meleagris	obtusus
Build nest	no	yes	no
Spawning site	riffles or pools	riffles or pools	pools
Water temperature at spawning	72°F.	70°F.	60–64°F.
Holds territory	yes	yes	no
Aggressiveness between males	yes	yes	no
Clustering over a female	yes	yes	no
Males swimming under or in front of female	yes	no	no
"Leading" behavior	no	no	yes
Rooting for eggs	yes	severe	severe
Males consort on riffles	yes	no	yes
Nuptial tubercles on males	well developed	heavily developed	poorly developed
Pectoral fin color	orange to red	red to rust	orange
Lateral band color	orange to red	red to rust	orange
Female color	normal	normal	yellow-green tinted

[1] Information on *atratulus* from Traver (1929) and on *meleagris* from Raney (1940).

During lulls a male may foray upstream into the riffle and may attempt to spawn with other males. Much scraping of the ventral fins or ventrum occurs before they move back over the breeding site. The female was not observed to approach the riffles to investigate these activities. Perhaps, it was a mixture of leading and prodding that Traver (*op. cit.*: 119) noted for *atratulus* males "consorting" on riffles.

The male of *obtusus* does not fight or guard a territory. This contrasts with the aggressiveness noted in *meleagris* by Raney (*op. cit.*: 400) where males battle when one strays into another's "territory." Neither does *obtusus* chase or aggregate over females as Traver (*op. cit.*: 119) and Raney (*op. cit.*: 402) noted during the spawning of *atratulus* and *meleagris*. During lulls in spawning activities male of *obtusus* may root

engage in nest building. Breeding activities commenced shortly after 11 AM and were most intense by 1 PM; such activity diminished by 3 or 4 PM at which time long shadows crept across the pools.

The breeding male of *obtusus* on the fin and mid-lateral body stripe is a brilliant orange. The breeding female develops a yellow-green tint especially on the belly which covers her usual pale brown body color. Females are non-tuberculate. The male at the height of the breeding season is sparsely tuberculate over the head, snout and nape. Nuptial tubercles also occur on the body in an area posterior to the opercles and extend from the nape to and along the pectoral fins, on the belly between the pectoral and pelvic fins and along the caudal peduncle. Each scale on the belly usually possesses two tu-

bercles located one in front of the other. Tubercles are found on the anal fin and at its base. Tubercles on the dorsum of the pelvic fins are the most conspicuous and sturdy, all others being small, weak and easily rubbed off. Two year or older males develop color and tubercles. Younger males do not spawn and retain a black lateral band and brown body color. Males, by year class, are generally smaller than females. Likewise, the female is the larger of a spawning pair.

At other than the spawning season the sexes can be separated by the length and shape of both pectoral and pelvic fins. The pectoral fin is longer in the male and occupies one-half the pectoral-pelvic space, while in the female the fin is shorter and occupies one-third this distance. In the male, the pelvic fin is square; in the female, the pelvic fin is pointed and longer, the point being most lateral. The pelvic fin character holds for the three subspecies and is not as reported by Traver (*op. cit.*: 118) where the condition in *atratulus* as pictured is reversed. In the male the posterior border of the pelvic fin approaches the anal papilla and reaches to or slightly beyond the anal fin base. The length of the anal fin divided by the length of the pelvic fin is 1.1–1.2 for the male and 1.45–1.55 for the female. See Raney (*op. cit.*: 339) for a comparison with *meleagris*.

Compared with the other two subspecies, the most important difference in the spawning of *obtusus* is its choice of a site in the mid-water of a pool. It also seems to be the least aggressive and vigorous in its spawning activities. This is correlated with the weak development of the nuptial tubercles of the male. Although *obtusus* was observed to spawn later in the season than has been reported for subspecies *atratulus* or *meleagris*, this may be due to lower water temperatures in mountain brooks.

Appreciation is due Dr. Edward C. Raney, Cornell University, for his suggestions and review of the manuscript.—FRANK J. SCHWARTZ, *Maryland Department of Research and Education, Chesapeake Biological Laboratory, Solomons, Maryland. Contribution from the Chesapeake Biological Laboratory No. 111.*

A FEMALE CERATIOID ANGLER, *CRYPTOPSARAS COUESI* GILL, FROM THE GULF OF MEXICO, BEARING THREE PARASITIC MALES.—On February 17, 1956 the Fish and Wildlife Service vessel, the M V OREGON, took a large female ceratioid angler bearing three parasitic males. The collection was made with a shrimp trawl at Oregon Station 1448, in 240 fathoms depth, about 70 miles south of Mobile Bay (29° 15′ N. and 87° 45′ W.). The bottom temperature was 10.5° C.

The entire basal bone of the illicium, or "bait", which had been recently torn off, presumably by the trawl, was represented by the shred of tissue near the head (Fig. 1). A fourth male had also been torn off or had recently died and disintegrated, and only a stiff strand 8 mm. long, resembling a fin ray, remained. The scar to which it was attached was intermediate in size between that of the largest male and the two smaller ones, and was located between the two smaller ones (Fig. 1 and inset).

The female was 176 mm. standard length (198 mm. to the end of the frayed caudal fin), with yellowish eggs protruding about 2 mm. beyond the genital opening (Fig. 1). A mass of clear gelatinous material surrounded and extended about 20 mm. beyond the eggs. This fish appeared to be identical to the type of *Cryptopsaras couesi* Gill (33,558 U.S.N.M.) with which Gordon Gunter compared it in March 1956. He also examined a 58 mm. specimen collected from the Gulf of Mexico (U.S.N.M. 39,483).

We have examined another specimen 80 mm. in standard length (104 mm. total length) taken from *Pelican* Station 30 (29° 20′ N. 80° 05′ W.) at a depth of 200 fathoms. In its depth (36 mm.) and radial formula it agrees with the other specimens of *C. couesi* examined. The largest female, without an attached male, reported (Kotthaus and Krefft, 1957, Ber. Dtsch. Wiss. Komm. Meeresforsch. XIV(3): 169–191) was 170 mm. long and came from the North Atlantic near Iceland.

The largest male (Fig. 1) was attached to the female by an expanded disc 12 mm. across and posterior to the other two males. It was 37 mm. from the anterior end of the snout to the base of the tail or 45 mm. to the tip of the tail. The depth was 11 mm. or 3.6 in the length. The center of the tiny eye was 10 mm. from the anterior end of the snout and the gill opening was 19 mm. from it. The uppermost male was 21 mm. long and the lowest one was 16 mm. in standard length. There was no trace that any of the three caruncles (present on the female anterior to the dorsal fin, Fig. 1) had ever been present on the males. There were also no "baits" or indications that they might have been torn off, except for the structure protruding from the scar of the missing male which was probably a modified basal bone. Bertelsen (1951, Dana Rept., 39: 1–276) described in the male a modification of the basal bone and other bait structures into a clasping device serving to assist in the attachment to the female.

The amount of pigmentation of the males was

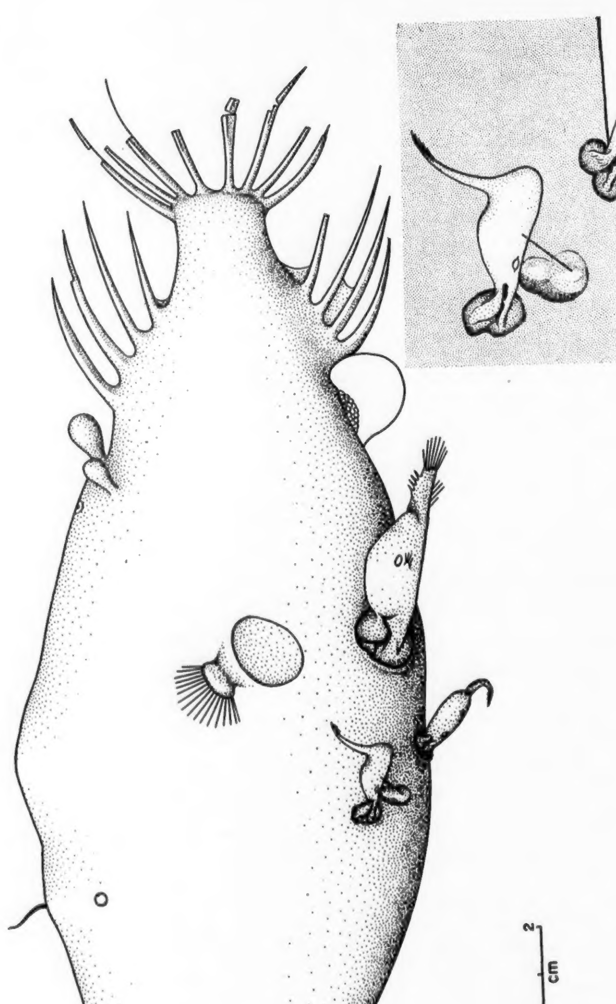

Fig. 1. Female *Cryptopsaras couesi* bearing three parasitic males

Fig. 1. Female *Cryptopsaras couesi* bearing three parasitic males

the same as the female, confirming the observation of Fast (1957, COPEIA (3): 240). Dermal denticles covering the males were about the same size as the ones of the large female, making them proportionately much larger. Bertelsen (1951, *op. cit.*: 145) indicated that the skin of the male was not known to have dermal denticles.

Histological sections were made through the region of attachment of one of the males to determine whether the circulatory systems were fused. It was quite clear that blood sinuses in this area communicated directly with blood vessels of both male and female. The vascular systems of male and female *Ceratias holboelli* have likewise been shown by Regan (1925, Proc. R. Soc. B., 97) to have an open connection.

Bertelsen, (1951, *op. cit.*: 144) who first described the free living adolescent male of this species, stated that only one parasitic male of this species was known. This was the specimen illustrated in Barbour (1941, Proc. New England Zool. Club, 19: 7–14), which Bertelsen interpreted as being degenerate, "the whole of the caudal region including the peduncle" being wanting. The original figure of the 440 mm. female (the largest known) bearing the above male was made by Tanaka (1911, Fishes of Japan, vol. II) who did not recognize the appendage as a male. The posterior ends of the three males taken by the M V OREGON were as complete as that of the female, with 8 caudal, 4 dorsal and 4 anal rays each. This suggests that Tanaka's male had been injured and healed which is the view shared by Fast (1957 COPEIA (3): 237–240) who found two complete males on a 213 mm. (standard length) female in Monterey Bay.

In a paper published just before the latter, and therefore not referred to, Marion Grey (1956, Fieldiana, Zool., 36(2): 75–337) listed a record of a second female bearing a parasitic male and has since stated by letter that this was the discovery of Abe and Nakamura (1954, Japanese Jour. Ichthy., 3(2): 95–96). The male was 15 mm. in total length (12 mm. standard length), and attached to a female 435 mm. in total length (276 mm. standard length) taken off Japan. The capture by the M V OREGON is unique in several respects; the female was the smallest known to bear parasitic males, one of the males was the largest known and on no previous female was there known to be more than two parasitic males.

A year around spawning was suggested by Bertelsen (1951, *op. cit.*: 198–207), who found larvae present in the Atlantic most of the year. This view is supported by the finding of eggs extruding from both the M V OREGON specimen, taken in February, and the Monterey Bay specimen taken in September. The size of the eggs of the former though not measured are approximately the same size as those measured by Fast (1957, *op. cit.*: 238) which were up to 0.49 mm. in diameter.

At the site of the dorsal tentacle, described by Fast (1951, *op. cit.*: 240) and just anterior to the caruncles there was a pore in the skin outlined by darker pigment. This is consistent with Bertelsen's (1951, *op. cit.*: 18) statement that when the basal bone is drawn posteriorly in a groove on the back, it emerges with its posterior end covered with skin which had been invaginated into the canal, thus forming the dorsal tentacle. It is therefore surprising that such a tentacle should be present on Fast's specimen which had the basal bone pushed forward.

Part of the work here reported was financed by a National Science Foundation Grant to the Gulf Coast Research Laboratory.—HURST H. SHOEMAKER, *University of Illinois, Urbana, Illinois, and Gulf Coast Research Laboratory, Ocean Springs, Mississippi.*

THE ORIGINAL DESCRIPTION OF THE CHINESE PARADISEFISH, *MACROPODUS OPERCULARIS* (LINNAEUS).—Although Myers (1932, Lingnan Sci. J., 11: 385–403, pls. 6–7) worked out the characteristics and synonymies of the two species of the genus *Macropodus* that occur in China, and showed that their scientific names should be *M. opercularis* (Linnaeus) and *M. chinensis* (Bloch), there are ichthyologists who adhere to the name *M. viridi-auratus* Lacépède for the former species (e.g., Nichols 1943, with the explanation that "*Labrus opercularis* of Linnaeus is not specifically identifiable").

The earlier data about the original description of the Chinese paradisefish have not been brought together in the ichthyological literature. In Linneaus' own publications we find the following accounts:

1754 (SCIAENA) fasciata. Specimen Academicus sistens CHINENSIA LAGERSTRÖMIANA. (Academical thesis, defended by Johannes Laurentius Odhelius). Stockholm, Jacob Merkell. Page 22, no. 4.

1758 LABRUS opercularis. Systema Naturae. Editio Decima. Stockholm. Laurentius Salvius. Tomus I, page 283 (with reference to *Chin. Lagerstr.* 24).

1759 LABRUS (opercularis). Amoenitates Academicae; seu dissertationes variae PHYSICAE, MEDICAE, BOTANICAE, antehac seorsim editae, nunc collectae et auctae, CUM TABULIS AENEIS. Vol. Quartum. Stockholm, Laurentius Salvius. Page 248.

1766. LABRUS opercularis. Systema Naturae.

Editio Duodecima, Reformata. Stockholm, Laurentius Salvius. Tomus I: 474 (with reference to *Amoen. acad.*, 4: 248).

1788 LABRUS (opercularis). Amoenitates Academicae, etc. Editio Secunda. Vol. Quartum. Erlangen, Iacob Palm. Page 248.

The above descriptions from the hand of Linnaeus are based on one type specimen, contained in those collections of natural history specimens, which the Councillor of Commerce and one of the Directors of the Swedish East India Company, Magnus Lagerström, presented to Linnaeus in 1748 and 1750 and which, after that, entered the natural history collections of the University in Uppsala as "Donatio Magni Lagerström." In the year 1754 Linnaeus published an academical thesis about these collections, which was defended by J. L. Odhelius. This thesis contains the first description of the Chinese paradisefish, with the binary name of *Sciaena fasciata*.

As this small paper, consisting of 36 pages, seems to be very rare in foreign libraries, I am here reproducing this description, which, in regard to the reference in Systema Naturae (Ed. 10: 283) must be regarded as the original description of *Macropodus opercularis* (Linnaeus, 1758).

24. SCIAENA (fasciata) *fasciis decem, maculaque operculorum fuscis.*

Corpus lividum, fere uti paralellograma extensum fasciis transversis, plusqvam X fuscis.

Caput a tergo maculatum, & macula fusca ad extremitates operculorum branchialium.

Pinna dorsalis radiis XX, qvorum XIII primores breviores, spinosi.

Pinnae pectorales radiis XI.

Pinnae ventrales radiis VI, primo spinoso, duo in setam exeuntes.

Pinna ani radiis XXVIII, primis XV spinosis, brevioribus, omnibus simplicibus.

Pinnae caudae radiis XVI.

In the standardizing 10th edition of Systema Naturae, Linnaeus has changed the name to *Labrus opercularis* and shortened the description:

L. cauda bifida, corpore fasciis 10, maculaqae operculorum fuscis. *Chin. Lagerstr.* 24. D. 13/20. P. 16. V. 1/6. A. 15/28. C. 16. *Habitat in* Asia.

The fin formula, as given in the Systema Naturae, is somewhat puzzling and has possibly contributed to the opinion that *Labrus opercularis* of Linnaeus may not be identical with the paradisefish. On comparison with the description in Chinensia Lagerströmiana it is, however, quite obvious that Linnaeus meant that the dorsal fin contains 13 spinous rays of the total number of 20 fin rays and that the anal fin contains 11 spinous out of 28, i.e., as expressed nowadays, D. XIII, 7 and A. XI, 17.

The description in Chinensia Lagerströmiana of 1754 was later published again, with some insignificant alterations, in both the editions of Amoenitates Academicae (1759 and 1788) although in each the species is, as in the Systema Naturae (1758), called *Labrus opercularis*. In both editions is added, referring to the *Pinna dorsalis*, "Pinnae haec apica in setam exit." Concerning the Pinnae ventrales, "duo in setam exeuntes" (1754) is replaced by either "secundam in setam exeunte" (1759) or "secundo in setam exeunte" (1788). Finally, "*Pinnae caudae*" (1754) is replaced by "*Pinna caudae* . . . bifida".

The rather good description, which Linnaeus published in 1754 and which is the basis of his short diagnosis in the tenth edition of Systema Naturae, is quite adequate for the conclusion that *Labrus opercularis* of Linnaeus 1758 (i.e., *Sciaena fasciata* Linnaeus 1754) is the same fish species which Lacépède, in "l'an X de la République" (1802), has described and figured after a Chinese painting, as *Macropodus viridiauratus* (Hist. Nat. Poiss., 3: 416–417, pl. 16, fig. 1).

Linnaeus, as mentioned above, based his description of the species on a specimen in the Lagerströmian collection in the museum of the Uppsala University. Unfortunately, this specimen is lost and, according to Holm (Acta Univ. Upsaliensis, 1957, 6: 39) was missing at an inventory made in 1780.

As regards the origin of the specimen described by Linnaeus, no further particulars were mentioned by the latter in Chinensia Lagerströmiana, and in the Systema Naturae he mentions only "*Habitat in* Asia". There should, however, be no doubt that the specimen in question belonged to those natural acquisitions which, by the orders of Lagerström, were collected by the personnel on the Swedish East India Company's sailing vessels, which were travelling to China. These had their Chinese port in Canton and one should be able to regard the vicinity of Canton as the *terra typica* for *Macropodus opercularis*.—HIALMAR RENDAHL, *Vertebrate Department, Swedish Museum of Natural History, Stockholm 50, Sweden.*

RAISING THE ATHERINID FISH, *MENIDIA MENIDIA*, IN THE LABORATORY.—As a prerequisite to a study of the development of schooling behavior, it was necessary to raise a number of *Menidia menidia* (Linnaeus), a common species of American silverside, from the embryonic stage to fry at least 15 mm. long. The

work was carried out at Woods Hole, Mass. during the summer of 1957.

Developing embryos were collected in the field, or eggs were stripped from gravid females and fertilized in the laboratory. They were reared in finger bowls, and when hatched, the 5 mm. long larvae were transferred to a wooden rectangular trough, 4′ long and 1½′ wide, filled to a depth of 2″ with running sea water at a temperature of approximately 22° C.

After the yolk sacs had been absorbed, generally by the fifth day post-hatching, the larvae were fed a variety of foods such as; larvae of *Arbacia* and *Crepidula*, diatoms, powdered fish foods and *Artemia*. Apparently they ingested some of these foods, but it was impossible to raise the larvae beyond the eighth day. However, if feeding was initiated by the second day, post-hatching, while they still had a conspicuous yolk sac, excellent survival rates were obtained.

The most satisfactory diet consisted of newly hatched *Artemia*. Although the two-day old larvae were incapable of ingesting them whole, they were able to tear off appendages. Generally, by the sixth day post-hatching these *Menidia* larvae consumed entire *Artemia*, as was verified by examination of the stomach contents. Evidently when larvae are reared in the laboratory, the age at which they are first fed is critical. Larvae with yolk sacs almost fully absorbed may be close to starvation and therefore unable to effectively utilize the new food source. An additional food source is necessary long before the yolk is completely absorbed in order to insure survival and adequate growth.

At the termination of these experiments a total of 90 fish had been successfully reared, some of which were kept for 48 days and reached lengths of 27–30 mm.

Supported by the Office of Naval Research under contract to the Marine Biological Laboratory, Woods Hole, Mass.—IRA RUBINOFF, *Queens College, Flushing, New York.*

CORRECTION FOR "THE FROGFISHERS OF THE FAMILY ANTENNARIIDAE BY LEONARD P. SCHULTZ, NO. 3383, PROC. U.S. NATIONAL MUSEUM, 1957.—*Antennarius pauciradiatus* Schultz, page 101, last line should read "no pelvic ray divided." The drawing is in error, as the last pelvic ray is simple, but all anal rays are divided. Therefore, in the key on page 62, section 52b. should be transposed to page 61 under section 49a. Dr. James Böhlke suggested that I check on the species which revealed the above errors.—*Leonard P. Schultz, U.S. National Museum, Washington, D. C.*

Herpetological Notes

FIRST RECORD OF THE RIDLEY TURTLE FROM BERMUDA, WITH NOTES ON OTHER SEA TURTLES AND THE TURTLE FISHERY IN THE ISLANDS.—On March 31, 1949, an Atlantic Ridley turtle, *Lepidochelys kempi* (Garman), was captured by Mr. George Lima who grasped the turtle's flipper as the animal drifted, apparently asleep, near Mr. Lima's fishing boat in the vicinity of Warwick, Bermuda. The 15-pound turtle was brought to the Government Aquarium at Flatts, where it is still living. In mid August, 1957, the turtle weighed 40 pounds and measured 18½ inches in carapace length and 18¾ inches in carapace width (both measurements taken in a straight line between perpendiculars, the length at the ends of the midline of the carapace, the width at its widest point, not in a curved line over the shell). Only the weight was obtained at the time of capture, but interpolating from the length-weight data for this species presented by Carr and Caldwell (1956, Amer. Mus. Novitates, No. 1793: 20, 22) the turtle must then have had a carapace length of approximately 14 inches. That the turtle is *L. kempi* and not a waif *L. olivacea* is clearly shown by its five pairs of laterals and its grayish color (Carr, 1952, Handbook of Turtles: 396).

Goode (1877, Amer. Jour. Sci. & Arts, 114: 290) did not list the Ridley from Bermuda, nor did Garman (1884, Bull. U. S. Nat. Mus., 25: 287), though both writers listed the other four species of North Atlantic sea turtles. Dr. Archie Carr of the University of Florida, who has made a particular study of the Ridley, tells us that he knows of no previous records for it from Bermuda, nor from anywhere on the seaward side of the Antilles Current or Gulf Stream, the latter a point which is perhaps even more zoogeographically significant. Carr (*loc. cit.*) notes that juvenile Ridleys have been taken on the Atlantic coast of North America as far north as Massachusetts, and also in England, Ireland, the Scilly Isles, and the Azores. He later (Carr, 1956, The Wind-

ward Road: 15) includes southern France. Bleakney (1955, COPEIA (2): 137) lists the species from Nova Scotia. Carr (1952: 398) also noted that he believed that the Atlantic records are based on individuals which are "lured, or swept, northward [and to Europe] by the reasonably warm current of the Gulf Stream" from the Gulf of Mexico, the only region in which the species is abundant. Sverdrup, Johnson and Fleming (1942, The Oceans: chart VII) show a gentle swirl or drift from the Gulf Stream which bathes Bermuda. It would be expected, therefore, that juvenile Ridleys such as ours might occasionally reach these islands, as do itinerant individuals of many animal groups. Actually, then, though word-of-mouth reports of its occurrence have been received in past years by Mowbray, it is surprising that a specimen of this turtle has not been reported there before now.

Although there is no organized sea turtle fishery in Bermuda, a few turtles, fewer than 100, are taken by fisherman each year. Most of these turtles are the Atlantic Green, *Chelonia m. mydas* (L.), though some Hawksbills, *Eretmochelys i. imbricata* (L.), are taken for food also. The Atlantic Loggerhead, *Caretta c. caretta* (L.), is frequently seen by fisherman, but is not pursued. The Atlantic Leatherback, *Dermochelys c. coriacea* (L.), is occasionally seen but not fished for.

Though an occasional turtle may come ashore to lay its eggs on the islands' beaches, there is no regular nesting there today by any of the species, nor has there been for many years. Study of the accounts of the party of Sir George Somers, wrecked in Bermuda on July 28, 1609, and of subsequent recorders, discloses the fact that many very large turtles were found. Turtles large enough to feed fifty men were taken, "and one Tortoyse would go further amongst them than three hogs. One turtle feasted well a dozen Messes, there being six men to every Mess ... their eggs are as big as geese eggs, and themselves grown to perfection, bigger than great round Targets." It was said that the eggs of one were far larger than those of the others, indicating that the Leatherback nested in Bermuda at that time. Garman (*op. cit.*) indicates that turtles nested in Bermuda at least as late as the late 19th century, but it is not clear from his remarks which species. It is assumed, however, that at least the Green turtle is included since it is noted by him as "the common turtle of the Bermudas". The only recent evidence of nesting consists of several eggs found uncovered by storm waves on the beach near Warwick in 1955. The eggs, from an undetermined species of sea turtle, were found at high tide and were presumed to have been washed out of an unseen nest lower on the beach. Even by his time Garman notes that the once abundant large sea turtles were rapidly disappearing from Bermuda due to the depredations of turtlemen, and today the largest Green turtles taken there range in weight from 125 to 140 pounds, with the majority weighing only 40 to 60 pounds. Furthermore, none are reported with eggs. These data are remarkably similar to those reported for Green turtles now found on the Florida Gulf coast (Carr and Caldwell, *op. cit.*), and indicate an itinerant population of juveniles, probably derived from the West Indies, the coasts of the Caribbean mainland, or both, and carried to Bermuda each season by the Gulf Stream.

Although Goode (*loc. cit.*) reported the Leatherback from Bermuda, supposedly for the first time (*fide* Garman, *op. cit.*: 290), the following earlier record is included here, not primarily for that reason, but because it includes a few measurements made on a specimen of this infrequently captured species. The quotation is taken from the *Bermuda Gazette*, dated July 14, 1835, and refers to a turtle taken in Bermuda waters a few days previous: "Very much resembling the common turtle; was taken by some fishermen on the 'grouper ground', on the south shore, and taken to Hamilton. Shell on back 'ridged', not unlike the bottom of a clinker-built boat. Seven feet long, 3½ feet [wide]; head-fin three feet six inches long and 15 inches broad; lower fin two feet four inches long, 14 inches broad; length of head 10½ inches; neck nine inches; estimated weight 1200 pounds." The large eggs mentioned above, from the accounts of 1609, if actually referrable to the Leatherback turtle, represent a still earlier record for this species in Bermuda.

We wish to thank Dr. Carr for his critical examination of this manuscript.—LOUIS S. MOWBRAY, *Government Aquarium and Museum, Flatts, Bermuda,* AND DAVID K. CALDWELL, *United States Fish and Wildlife Service, Brunswick, Georgia.*

REPRODUCTION IN CAPTIVE CORN SNAKES, *ELAPHE GUTTATA GUTTATA*.—We have had four corn snakes lay fertile eggs at a young age and small size. The four snakes are part of a litter hatched September 16, 1955 from a clutch of eggs laid June 18, 1955. The lengths given are for March 1, 1957, when the snakes were approximately 18 months of age. Gestation is regarded as the period of time between the first observed copulation and egg laying. Incuba-

tion is the period of time from egg laying until the young actually emerged from the eggs. The eggs were incubated at room temperature.

Snake 1: Length 29 inches. Copulation observed April 4, 1957. Deposited 8 eggs May 30, 1957. These eggs were adherent to each other and averaged 34.8 by 19 mm.

One egg was opened immediately and no embryo was found. Two of the eggs were fed to another captive snake. The remaining eggs became moldy and only one could be salvaged. This egg hatched on August 13, 1957, though the hatchling made the first egg slit on August 11, 1957. Length of the hatchling was 10 inches. Gestation 56 days. Incubation 73 days.

Snake 2: Length 23 inches. Copulation observed March 18, 1957 and with two separate males March 19. Deposited 6 eggs May 11, 1957. These were not adherent and averaged 38.1 by 17.8 mm.

One egg was opened immediately and found to contain a living embryo. The remaining eggs became moldy and were sprinkled with mycostatin (an antibiotic effective against some fungi). Two eggs appeared to be salvaged. One of these, opened June 28, contained a normally-developing living embryo. The last one, after passing the anticipated hatching date, was found to contain a deformed, fully-developed, dead snake. The ventrum of this snake had never closed and the folds, where the snake was coiled in the egg, were joined by permanent adhesions. Gestation 54 days.

Snake 3: Length 21 inches. Copulation not observed. Deposited 5 eggs May 19, 1957, four of them adherent to one another. These eggs averaged 35.6 by 17.8 mm.

One egg was opened June 1 and found to contain a normally developing embryo. The remaining 4 eggs solidified. When these were examined 2 were found to contain dead embryos which had been developing normally up until the eggs spoiled.

Snake 4: Length 27 inches. Copulation observed March 19 and April 4, 1957. Deposited 3 eggs May 26, 1957, not adherent. These eggs averaged 52.3 by 15.7 mm.

These elongated eggs hatched between August 7 and 9, 1957, producing normal hatchlings 12, 11½, and 12 inches in length. Gestation 68 days. Incubation 73 days.

We had known, from previous experience with snakes of this species, that the male could reach sexual maturity at about 18 months of age, but we had more or less assumed that the females would not be ready for breeding until the spring of 1958. It came as a surprise, therefore, when all 4 of our young females, including one only 21 inches in length, bred successfully in 1957. The young produced by these young females were as long as those produced by a large adult female.—H. Bernard Bechtel and Elizabeth Bechtel, *3359 Meadow Court, Indianapolis, Indiana.*

MATERIAL INGESTED BY THE COTTONMOUTH, *AGKISTRODON PISCIVORUS*, AT REELFOOT LAKE, TENNESSEE.—Allen and Swindell, Copeia (1948 (4) First Suppl.: 1–16) reported that the cottonmouth moccasin of Florida eats a wide variety of living food, including snakes, frogs, turtles, fish, lizards, birds and mammals, in addition to carrion. Four cottonmouths were collected from a small slough on the west side of Reelfoot Lake, Tennessee, May 20, 1947 as they were basking. When these snakes were examined for parasites, the following food items were noted: beetles in one stomach; lizard (*Eumeces*) in another stomach; small snake (*Natrix*) in one intestine, and hair in another intestine. One stomach contained numerous bits of wood, up to four inches in length, presumably fragments of bald cypress.

Glaser, Copeia (1955 (3): 248) reported the occurrence of a rock in the intestine of the spotted nightsnake, *Hypsiglena torquata ochrorhyncha*, and speculated that possibly the rock was ingested because it had been rendered acceptable through contact with an accustomed food item. Kauffeld (Herpetologica 1953 (9): 129) mentioned the efficacy of placing cut beef strips in a cage with white mice prior to feeding them to prairie rattlesnakes, whereupon they apparently absorbed the mouse scent and were devoured voraciously by the snakes. In Klauber's recent (1957) comprehensive treatise on the rattlesnakes (p. 588) he mentioned the finding of a stone in the digestive tract of *Crotalus viridis caliginis* and of Ruthven (1907) finding a stone in *C. atrox*. The discovery of stones and of "pine knots" in the stomachs of alligators has been reported and is probably a fairly common occurrence in these animals, so much so that there is at least circumstantial evidence that they may serve some functional capacity. However, no explanation has been offered for the presence of extraneous items in snakes except that they were either inadvertently or purposefully swallowed as food items.—John D. Goodman, *Department of Biology, University of Redlands, Redlands, California.*

NOTES ON THE TOADS OF EASTERN SOUTH DAKOTA.—The central plains toad,

Scaphiopus bombifrons Cope, was reported from Vermillion, Clay Co., South Dakota by Chrapliwy and Findley (1956, Herpetologica 12(2), 124). During the summer of 1957 this toad was collected in Clay, Lincoln, Turner and Union Counties. Collections were made during or immediately following heavy rains. On the night of June 6, 1957 a breeding population of about fifty individuals was discovered three miles north of Vermillion. Fifteen young of the year were collected in Lincoln County on September 1, 1957. This toad is common in Union County east to a line approximately ten miles west of the Sioux River. Two parallel transects were run east and west of the Sioux River to determine the eastern limit of the range. The transects west of the river were from Hudson to Elk Point, South Dakota; the eastern transects were from Westfield north of Sioux City to Hawarden, Iowa. Spadefoots were collected on both the western transects but none was collected east of the Sioux River.

It is apparent that *Scaphiopus bombifrons* is common in southeastern South Dakota but it is impossible to accurately outline the distribution within the state.

Data on specimens deposited at the State University of South Dakota are: *Clay Co.*—3 miles north of Vermillion; 12 miles north of Vermillion; University Campus and Valley View, Vermillion; 3 miles south and 4 miles north of Dalesburg; 5 miles east of Wakonda. *Turner Co.*—4 miles west of Centerville. *Lincoln Co.*—2 miles south of junction of hwys. 17 and 18; 3 miles north of junction of hwys. 47 and 17; 5 miles east of Centerville. *Union Co.*—3 miles and 9 miles south of Beresford; 3 miles east of Spink.

The great plains toad, *Bufo cognatus* Say, is common throughout eastern South Dakota.

One American toad, *B. terrestris americanus*, collected at Garretson, Minnehaha Co., South Dakota on June 5, 1956 represents the first record from South Dakota. Over (1923, Amphibians and Reptiles of South Dakota) originally included this species in the amphibian fauna of the state but subsequently informed Bailey and Bailey (1941, Iowa State Coll. Jour. Sci. 15: 172) that the toads reported as *B. americanus* were actually *B. woodhousei*.

Bufo woodhousei Girard, Woodhouse's toad, is common in Clay, Lincoln, Turner, Union and Yankton Counties. It is common to the floodplains of the Vermillion, James, Sioux and Missouri Rivers, and has been collected only occasionally on the uplands. While the detailed range of this toad in South Dakota is yet to be determined, I take exception to Over's statement that *B. woodhousei* is the most common toad in South Dakota, particularly in the eastern half of the state.

The Dakota toad, *B. hemiophrys* Cope, is common in Day and Marshall Counties in northeastern South Dakota and has been collected as far south as Brookings County. Range discussions of the Dakota toad do not include South Dakota, although Wright and Wright (1949, Handbook of Frogs and Toads. p. 180) note without documentation that some range discussions include the state.

On May 18, 1956, nine mature males and five mature females were collected in a small pond east of Blue Dog Lake, Day County. Approximately 125 individuals were in the pond. On July 6, 1956, seven newly metamorphosed individuals were collected from this same pond and on August 11 twenty-seven young of the year were collected west of the pond. On May 11, 1957 a number of males were present but no females were discovered in or near the pond. A single female was collected this same day in a small pond south of Enemy Swim Lake, Day County. A large population of *B. hemiophrys* was discovered at Clear Lake, Marshall County on July 26, 1957, and early in August populations were found at Cottonwood and Buffalo Lake also in Marshall County. The most southern record of this toad in South Dakota is from a small pond in Brookings County, 3 miles east of the junction of highways 81 and 41.

Blair (1957, Texas Jour. Sci. 9(1): 99–108) presented evidence indicating that the Dakota toad is not conspecific with *B. woodhousei* as was suggested by Schmidt (1953, Check list of North American Amphibians and Reptiles. p. 67). The ranges of the two species in North Dakota overlap or are contiguous in Cass, Grand Forks and Ward Counties (Wheeler, 1947, Am. Midl. Nat. 38: 174–177), and it is suspected that further collecting in South Dakota will reveal a similar situation. The range of the Dakota toad as known at present includes northeastern and eastern North Dakota in the Red River valley south to Richland County; northwestern and west central Minnesota (Breckenridge, 1944, Amphibians and Reptiles of Minnesota. p. 63) south to Traverse County (Blair, 1957, Texas Jour. Sci. 9(1): 99–108). The specimens reported from South Dakota extend the range of the Dakota toad slightly farther south.

I acknowledge the kindness of Dr. Walter Breckenridge for checking the identification of certain Dakota toad specimens and Mr. Byron Harrell for many helpful suggestions during the preparation of this note. The field work was made possible by a grant in aid from the Research Fund of the State University of South

Dakota.—JAMES C. UNDERHILL, *Department of Zoology, State University of South Dakota, Vermillion, South Dakota.*

THE NAME *CROTALUS VIRIDIS CONCOLOR* WOODBURY.—In accordance with a suggestion from the Committee on Herpetological Common Names, attention is called to Opinion 339 (Opinions and Orders, 10: 181–200) of the International Commission on Zoological Nomenclature issued March 17, 1955, which brought an official end to a long controversy over the above name by providing for "Acceptance of the name *concolor* Woodbury, 1929, as published in the combination *Crotalus concolor*, as the name for the Yellow Rattlesnake of the Colorado River Basin".

This name had been accepted in the older Stejneger and Barbour Check Lists but was questioned by Gloyd in his account of the rattlesnakes, 1940 (Spec. Publ. Chicago Acad. Sci., 4: 216) and in the Schmidt Check List of 1953, following Gloyd, was replaced by *decolor* Klauber, 1930 while the case was being considered by the International Commission. Gloyd challenged the name *concolor* Woodbury, 1929 on the ground that it was preoccupied by *concolor* Jan, 1859, "a *nomen nudum*", an illegal name which he assumed had been validated by the simple process of being cited in a synonomy by later authors antedating Woodbury.

The case went to the International Commission as a question about the basic philosophy involved, essentially: Can an illegal name, a *nomen nudum*, be validated by a subsequent author simply by citing it allocated to the original author in synonomy, without complying with the International Rules by including a description and using his own name as author? The Commission decided (1953, Copenhagen Decisions Zool. Nemencl.: 63, Decision 115 (a)) in essence that a non-legal name could never be made valid by the process of synonomy citation; it would require fulfillment of the obligations of the International Rules in a new treatment independent of the original citation to give it validity.

This decision in Opinion 339 was overlooked by the Committee on Herpetological Common Names and so was carried over in error to the list of Common Names for North American Amphibians and Reptiles.—ANGUS M. WOODBURY, *University of Utah, Salt Lake City, Utah.*

BUTLER'S GARTER SNAKE EATS AMPHIBIAN.—In the afternoon of April 19, 1957, I picked up a young *Thamnophis butleri* in a fallow field near Ann Arbor, Washtenaw County, Michigan. When forced to regurgitate, the snake expelled an adult-sized *Hyla crucifer*, with only the anterior part of the head disintegrating.

Carpenter's intensive study (1952, Ecol. Monogr., 22: 235–258) of *Thamnophis* near Ann Arbor produced no record of *T. butleri* feeding on amphibians. His data, like those of other workers, showed that it ate only annelids, mainly earthworms. It is thus more specialized in feeding habits than *T. sirtalis sirtalis*, which eats a variety of invertebrates and small vertebrates, and is sharply set off from *T. sauritus sauritus*, which feeds almost entirely on amphibians. In some places all three species occur together.

In experiments with caged snakes, Carpenter found that *T. butleri* ate amphibians, including *Hyla crucifer*. Their absence from food records for wild individuals he believed to be caused by the snake's difficulty in capturing them because of its relatively small head and mouth and its tendency to live in densely matted grass.

One would expect amphibians to be particularly difficult for a young snake, only 16.5 cm. in snout-anus length and presumably born the preceding August, to capture. April 19 was chilly, however, and a considerable number of sluggish hylas were found nearby, on the gentle slopes above the pond. The snake, perhaps warmed more than the frog in a different micro-environment, may thus have found it easy prey. The sparse vegetation may have been influential in allowing the frog and snake to meet.

An alternative explanation of the snake's capture of the amphibian is that small young of *T. butleri* may be less specialized in their feeding than older individuals.—FREDERICK H. TEST, *Department of Zoology, University of Michigan, Ann Arbor, Michigan.*

INDUCED OVULATION IN *NECTURUS*.—The desire to obtain eggs of *Necturus maculosus* during the winter months prompted attempts to stimulate ovulation artificially. Thirteen females, obtained from General Biological Supply House, were supposedly collected at Oshkosh, Wisconsin, in mid-December. This date is well after the mating season (Bishop, 1926, N. Y. State Bull., No. 268), and the animals were presumed to be carrying spermatozoa. In Michigan, where this work was done, the normal egg-laying season is May and early June (Smith, 1911, Biol. Bull., 20: 191).

Pituitary glands of *Rana pipiens* were utilized in the first experiments. A variable number (24 to 41) of pituitaries was injected into each of twelve *Necturus* on December 9, 1953, according to the method of Rugh (1948, Experimental Embryology). On February 2, all the animals were

alive and no egg-laying had taken place. At that time, 2–4 cc. of a concentrated and detoxified solution of human pregnancy urine, prepared by the technique of Weisman, *et al.* (1942, West. J. Surg., Obst., Gyn., 50: 557), was injected into these twelve animals. There was no reaction the first five days. On the sixth day after injection seven of the animals were dead or dying. By the seventh day ten animals had died. However, on this day, February 9, 35 eggs were found deposited on the underside of some metal sheets placed in the aquarium for this purpose. On the following morning ten more eggs were found. The two remaining animals survived until April, and no more eggs were deposited. None of the 45 eggs developed, and none developed a fertilization membrane or gave evidence of polar body formation. It is not known that the female(s) depositing the eggs had mated. It is possible that the eggs were not yet mature. Postmortem eaxmination of the ten animals which had died from the injections revealed that eight had begun to ovulate.

On March 3, 1954, tests using Parke-Davis "Antuitrin-S" were begun. This is a purified extract of the chorionic gonadotropin found in human pregnancy urine. Six recently received female *Necturus* were injected with from 100 to 900 units (500 units being a typical injection in humans). None of these animals showed effects from the injection by March 31. On this date these same females were injected with 2 cc. of the human pregnancy urine of the same type previously used. Two of the animals died from the injection, and no eggs were deposited. Postmortem examination of these two animals revealed no ovulation.

Inasmuch as the first group of twelve animals had received frog pituitary seven weeks before the urine injection, and the second group of six had received no pituitary, the findings are inconclusive. It is possible, however, that there was a synergistic effect of the frog pituitary and the chorionic gonadotropin.

Use of the Weisman extract introduces an experimental difficulty, for the concentration of the chorionic gonadotropin depends upon its concentration in the urine, which is highly variable.

Since the objective of obtaining fertile eggs in winter was not realized, the experiments were not continued.—Kenneth L. Fitch, *Department of Anatomy, University of Missouri Medical Center, Columbia, Missouri.*

THE STATUS OF *HALDEA* BAIRD AND GIRARD AND *VIRGINIA* BAIRD AND GIRARD.—When the monotypic genera *Haldea* Baird and Girard 1853 (Cat. N. Amer. Rept., pt. 1: 122) and *Virginia* Baird and Girard 1853 (*ibid.*: 127) were combined by Stejneger and Barbour in the 1939 Check List, *Haldea* was chosen as the generic name, possibly on the basis of page priority. Overlooked was a prior generic synthesis by Garman (1883, Men. Mus. Comp. Zool., 8 (3): 96–99) in which he clearly assumed the role of first reviser and selected *Virginia* in preference to *Haldea*. Under the effective International Code of Zoological Nomenclature, *Virginia* Baird and Girard is the valid name of the genus, (1953, Copenhagen Decisions, Art. 28).

The name *Virginia* was in use for the species *valeriae* Baird and Girard from 1853 until 1938, (81 literature citations). *Haldea* was the generic designation for *striatula* Linnaeus from 1853 to 1917 and again in 1938, (23 citations), when *Potamophis* Fitzinger was declared preoccupied (Parker, 1938, Copeia (2): 94). It has been used in the congeneric sense for the past 19 years, (59 citations). Suspension of the rules would be necessary in order to validate *Haldea* and suppress *Virginia*.

Since neither technical considerations, familiarity, period of official use, nor frequency of publication would support a petition for suspension of the rules, such a request is judged inadvisable.

This matter was brought to the attention of the late K. P. Schmidt in a letter. His reply, written four days before his death, is quoted in support of resumption of the use of *Virginia*. "My own preference between *Haldea* and *Virginia* for the two species *striatula* and *valeriae*, is plainly in favor of *Virginia*. Euphony and familiarity carry much weight with me, and the case for *Virginia* is good on purely formal grounds. I would certainly follow you in the next check list (if I live to do one), if you publish this matter.

It does not seem likely that Stejneger or Barbour had any real reason for introducing *Haldea* in the comprehensive sense."—Louise D. Zillig, *Department of Zoology, Duke University, Durham, North Carolina.*

SYMPATRY OF THE YOSEMITE AND WESTERN TOADS IN CALIFORNIA.—The northern limit of the Yosemite toad, *Bufo canorus* Camp, is recorded as 1.5 miles south of Ebbetts Pass, 7800 feet, Alpine County (Livezey, 1955, Herpetologica, 11: 212). Its southern limit is 5 miles south of Kaiser Pass, 9000 feet, Fresno County. The total range of the species is a boreal section of the Sierra Nevada approximately 130 miles in length (NW by SE) and 35 miles in width (NE by SW); its elevational range

is from 6400 to 11,300 feet in the Yosemite Valley region (Karlstrom, 1956, PhD thesis, Univ. of California, Berkeley: 12).

Bufo boreas, the western toad, completely encircles the Yosemite toad, and, south of the range of the latter, *B. boreas* attains an elevation of 10,200 feet in the Sierra Nevada (Stejneger, 1893, N. A. Fauna, 7: 220). Over most the Sierra Nevada the hiatus between the two species appears to be several thousand feet. In 1956 I was able to locate an area of sympatry at the northern end of the range of *B. canorus*.

The first clue that the two species occured together came through a study of toads in the Stanford Natural History Museum. Dr. Alex Calhoun collected two at Upper Blue Lake, 8100 feet. These were identified as *Bufo boreas boreas*. I determined that SNHM 6420 is an adult male *B. canorus*. The other, an adult female *boreas* (SNHM 5804) is typical for Alpine Country. Incidentally, the discovery of *B. canorus* at Upper Blue Lake extends the range of the species northwestward about 10 miles from the Ebbetts Pass locality reported by Livezey (*op. cit.*).

Sympatry was verified in June 30, 1956. Herpetologists can understand my elation in discovering the animals together after years of intensive searching. One adult *canorus* was collected along with 4 adult *boreas* under a log at the north edge of the lake. In addition, new eggs of the Yosemite toad were present in a nearby shallow pool. The total collection, 34 *boreas*, the single male *canorus* and *canorus* spawn, is deposited in the Museum of Vertebrate Zoology, University of California, Berkeley. Upper Blue Lake is situated in the Upper Canadian Life-zone. Lodgepole pines are dominant along the borders of the lake. Rapid snow melt produces numerous runoff streams that flow through an open stand of low willow at the north end of the lake where the toads were collected.

Studies by me substantiate the opinion of Stebbins (1951, Amphibians of Western North America: 245) that *B. canorus* is a montane differentiate of the *B. boreas* group. The geographic isolation of the Yosemite toad possibly occurred during the early Pleistocene glaciation of the Sierra Nevada. Today the essentially allopatric distribution of the species may be due largely to competition. I cannot find distinct evidence for intergradation of the species at the Upper Blue Lake locality or its vicinity in Alpine County. This suggests that the contact is secondary and of recent occurrence. Some differences in breeding time and sites were noted at Upper Blue Lake.

My thanks to Dr. Robert C. Stebbins, who read the manuscript, and to Dr. George S. Myers for making available material in the Stanford Natural History Museum.—ERNEST L. KARLSTROM, *Department of Biology, Augustana College, Rock Island, Illinois.*

RECORD LIFE-SPAN FOR A SNAKE (*Lampropeltis*).—The death of a specimen of *Lampropeltis doliata amaura* on January 7, 1957 that was captured on June 8, 1936 is a record for longevity for a snake of this size. This snake, 580 mm. long, weight 33 grams, had lived in captivity 20 years and 7 months and was undoubtedly over 21 years old, as it was about ten inches long when captured.

Emphasis might be placed on the fact that no special care, other than cleanliness and regular feeding of *anoles*, was given to this specimen.—GEORGE P. MEADE, *Pontchartrain Hotel, New Orleans, Louisiana.*

REVIEWS AND COMMENTS

ZOOGEOGRAPHY: THE GEOGRAPHICAL DISTRIBUTION OF ANIMALS. By Philip J. Darlington, Jr., John Wiley and Sons, New York, 1957: xi + 675 pp., 80 text-figs. $15.00.—The author of this thoughtful and stimulating book is Curator of Entomology at the Museum of Comparative Zoology, Harvard University, a systematist of note and a long-time student of animal distribution. Although, title to the contrary, Dr. Darlington restricts his account exclusively to terrestrial and freshwater vertebrates, there can be little question that this is the most important general discussion of the subject since Alfred Russell Wallace's classics, *The Geographical Distribution of Animals* (1876) and *Island Life* (1880).

The book is organized into five major parts.

The introductory section contains a brief but effective summary of the basic facts of world geography, climate and vegetation and a survey of fundamental zoogeographic concepts and working principles. Then follows an extensive group by group analysis of distribution patterns in the vertebrates, exclusive of marine forms. A chapter is devoted to each class and gives a succinct discussion of the major patterns for the group followed by a detailed summary of the known distribution of each living family. The chapter on freshwater fishes is outstanding, the one on amphibians only slightly less so, but the account of the reptiles suffers very much by comparison. This is probably due primarily to the fact that the systematics of the families and genera of living reptiles are not nearly as well known as for other terrestrial vertebrates. The third unit of the book is composed of two chapters on continental and insular distribution patterns based upon a synthesis of data presented in previous sections. The evolution of the major patterns and the light they throw upon faunal history form the topics for another pair of chapters. The final section deals with important generalizations about vertebrate distribution and a short account of the geography of man. Bibliographic references are given at the end of each chapter, but the style of citation is inadequate. Only a few key words or a phrase from the title of each article are listed.

Dr. Darlington's book is refreshing as a work on zoogeography in its lucid presentation, its well-done original maps and diagrams, its avoidance of circular reasoning (the bane of zoogeographers) and of the mere compilation of data unbalanced by critical evaluation. Sections that ought to be read by every biologist are the discussion of the nature of zoogeography as distinct from ecology (p. vii) and the relation between present and past zoogeographic patterns (p. 22); the brilliant essay on the significance of the concept of biotic regions (p. 419); and the excellent analyses of the difficult faunas of Central America (pp. 72–77, 279–287, 456–462), Wallacea (pp. 462–472) and the West Indies (pp. 510–517).

Based upon his survey of the occurrence of approximately 30,000 species of living vertebrates, Darlington reaches a number of important conclusions: 1) present distribution patterns are the result of animal dispersal, retreat and replacement during Tertiary and in some instances late Cretaceous times; 2) these patterns indicate that the continental land masses and ocean basins have essentially retained their present positions throughout the Tertiary; thus there have been no extensive trans-oceanic land bridges and no floating Wegnerian continents during this time; 3) all the major non-marine groups of vertebrates (almost all orders and most families) have originated in the old world tropics and radiated from there into the temperate areas and new world tropics; 4) competition explains the origin, dispersal, replacement and extinction of a group as it evolves and expands to compete with older groups and dies and loses ground as new major groups evolve to compete with it.

None of these conclusions is completely new, but the detailed support mustered by Darlington for most of them from group after group strongly re-inforces his views. Perhaps the single most controversial point lies in the conclusion that mammals follow the same pattern of tropical origin and dispersal seen in other vertebrates. This concept is a complete contradiction of Mathew's (1915, *Climate and Evolution. Ann. New York Acad. Sci.*, 24: 171–318) thesis of the Holarctic origin of major mammalian taxa.

It is unfortunate that Darlington failed to consider in more detail the available information on Tertiary palaeogeography and the picture of Tertiary climates gradually accumulating through the studies of palaeobotanists. The latter, especially, might have influenced his statements, repeated at several points in the book, regarding the stability of climatic zones and might have provided important evidence explaining the passage of tropic groups from Eurasia to North America via the Bering land connection. Also of value would be a consideration of vertical zonation and the importance of montane "islands" to zoogeography. Notably absent from the chapter on insular patterns is a discussion of the well-studied islands in the Gulf of California, Mexico. Darlington's criticism of the recent tendency to "split" genera into several units (p. 152 and elsewhere) is poorly conceived. Genera are not usually divided into several groups out of caprice, but to elucidate evolutionary patterns. The division of the formerly all-inclusive genus *Triturus* emphasizes that eastern (*Diemyctylus*) and western (*Taricha*) American species of salamandrids previously thought to be closely allied are actually very distinct from one another and are more nearly related to European and Asian forms, respectively. This conclusion is important zoogeographically and the significance would be hidden if both groups were still placed in a single genus.

In general the theories presented by Darlington on origins and affinities of major groups are cogent and convincing. However, two of his ideas need further study. Seriously questionable is his concept of an old world tropic origin of salamanders (p. 158). This group seems, in my

opinion, to offer the best case for exception to Darlington's Rule of old world tropical derivation.

Also of dubious merit is the conclusion that ostariophysan fishes originated in Eurasia, dispersed into North America and "passed through" an already existent non-ostariophysan freshwater fish fauna in the Nearctic on the way to the new world tropics. The problem centers around the age of the freshwater fishes of eastern North America as compared to that of the ostariophysan catfishes and characins. Inasmuch as most of the characteristic North American forms of non-ostariophysans are spiny-rayed it may be argued that they appeared on the scene after the more primitive soft-rayed ostariophysans. A plausible explanation of the situation suggests the idea that the primitive ostariophysans (catfishes and characins) originated in the old world tropics and moved from Eurasia into North America. There they replaced an earlier freshwater fish fauna represented by a few still surviving relicts such as the non-teleosts and hiodontids. As the primitive ostariophysans invaded the new world tropics from the north they seemed to have replaced an earlier fauna now represented by the relictual lungfish, osteoglossids and perhaps the Nandidae of South America. The catfish and characin fauna of the Neotropical Region was of course trapped and protected in South America during much of the Tertiary. However, possibly correlated with the recession of the tropics, the temperate families of spiny-rayed fishes and several soft-rayed groups apparently moved into North America from the old world and replaced most of the primitive ostariophysans. These newcomers, including the families Umbridae, Esocidae, Percopsidae, Aphredoderidae, Centrachidae and Percidae, have subsequently been replaced for the most part in western North America by a second radiation of ostariophysans (the cyprinids and their allies) and secondary freshwater fishes from the old world. The cypriniforms are now also in competition with the non-ostariophysans in eastern North America and may be replacing them.

In a very real sense Darlington's book marks the end of an era in the study of vertebrate zoogeography. It stands as the final chapter of the work on major world distribution patterns initiated a hundred years ago by P. L. Sclater (1858, *J. Proc. Linnean Soc. London,* 2: 130–145) and re-surveyed by subsequent students from A. R. Wallace to L. F. de Beaufort. There seems little doubt that our current knowledge of vertebrate distributions is such that the major patterns and conclusions presented by Darlington will be only slightly modified by additional study. But if this book marks the end of an era it also heralds a new one. With the basic world zoogeographic picture firmly established the vertebrate biologist can now concentrate upon new vistas. Firstly, he can turn his attention to the study of geographic subpatterns based upon the distribution of living genera and species within the major zoogeographic units. Secondly he can analyze in detail the probable historical shifts in generic and specific geographic ranges, particularly as influenced and controlled by climatic and physiographic factors. These two approaches in combination can answer such fundamental questions as: what are the patterns of distribution at the present time within the major zoogeographic regions? Where did the forms currently living in these subregions come from? To what other faunas do they show affinity? What do the patterns tell us about the origin, evolution and dispersion of living species and genera? The answering of these and similar questions not touched upon by Darlington, will produce the next major chapter in our understanding of the evolutionary distribution of vertebrates. A chapter which will have added meaning because of the magnificent background provided by Darlington's *Zoogeography*.—JAY M. SAVAGE, *Department of Biology, University of Southern California, Los Angeles, California.*

THE LUMINESCENCE OF BIOLOGICAL SYSTEMS. Edited by Frank H. Johnson. American Association for the Advancement of Science, Washington, D.C., 1955: xiv + 452 pp.—Herpetologists may be little interested in bioluminescence since there are no known naturally luminescent reptiles or amphibians, and living light creeps into the literature only through fireflies ingested by treefrogs and other devious routes. Sanderson's account of luminosity in the male teeid, *Proctoporus* (*Oreosaurus*) *shrevei* is believed to be either false or spurious (Harvey, 1952 *vide infra* p. 494); the reputed photophores are histologically similar to "reflection pearls" of certain nestling birds (H. W. Parker, 1939 J. Linn. Soc. Zool. *40:* 658–660). Those concerned with freshwater fishes similarly rarely encounter bioluminescence in their studies. The sea, however, teems with photogenic organisms; from bacteria to algae, from protozoa to fishes, and in the fishes from elasmobranchs to ceratioids. The majority of photogenic fishes are deep-water forms; their light is in some cases produced by the tissues of the fish itself.

As the deep-water material being gathered by various agencies accumulates and is subjected

to scrutiny, we can anticipate substantial advances in the knowledge of systematics, anatomy micro- and macro-), physiology, development, horizontal and vertical distribution, and kindred aspects of the deep-water fauna. The time is approaching for critical analyses of the dynamics of life in dim light and abyssal darkness. Light produced by living organisms apparently plays an important role in these regions, more so than in littoral and pelagic communities.

The two most recent comprehensive surveys of the state of knowledge of living light are "Bioluminescence" by E. N. Harvey (Academic Press, 1952) and the present compendium, which is reviewed belatedly here. Seventeen articles represent the proceedings of the Conference on Luminescence, held 28 March–2 April 1954 at Asilomar, near Pacific Grove, California. Topics covered which are of particular interest to ichthyologists are "Survey of luminous organisms: problems and prospects" by E. N. Harvey; "Spectroscopic investigations of luminescent systems" by C. J. P. Spruit and A. Spruit-van der Burg; "Factors and biochemistry of bacterial luminescence" by B. L. Strehler; "Inhibition and activation of intracellular luminescence" by F. H. Johnson; "Physiological control of luminescence in animals" by J. A. C. Nicol; "Some reflections on the control of bioluminescence" by J. Buck; "Luminous organisms of Japan and the Far East" by Y. Haneda.

A perusal of both Harvey's recent book and the present compendium reveals the primitive state of knowledge concerning light produced by fishes. The reviewer, for example, has searched for measurements of the emission spectra of fishes. For the most part all that is available are inexact statements that the light is bluish, greenish, yellowish, white, or combinations of the adjectives. Perhaps the use of recently-developed instruments of high sensitivity such as the bathyphotometer can be used to advantage here.—VLADIMIR WALTERS, *American Museum of Natural History, New York, New York.*

HOW TO KNOW THE FRESHWATER FISHES. By Samuel Eddy. Wm. C. Brown Co., Dubuque, Iowa, 1957: 253 pp., 615 figs., $2.75 (spiral bound), $3.25 (cloth bound).—This is one of the booklets in the Pictured-Key Nature Series edited by H. E. Jaques. It is a manual (8⅜ x 5½ inches) for the identification of the freshwater fishes of the United States and treats approximately 625 species, including a few that are euryhaline. About 450 species are illustrated. A key to the families, illustrated by outline drawings, follows a general introductory section on fish biology and structure. All genera are keyed out, but in several groups, particularly the Cyprinidae and Catostomidae, keys to species are frequently omitted—although distinguishing characters are given. The chief merit of this work lies in the illustrations, done by the author, which usually emphasize the distinguishing features remarkably well. The drawings alone are worth the price of the publication. The booklet should be used in conjunction with Moore's (1957) account of the fishes in "Vertebrates of the United States," in order to correct or modify some of Eddy's range statements and to make available additional keys. With these two publications at hand, the task of identifying freshwater fishes from the United States is greatly facilitated.—ROBERT RUSH MILLER, *Museum of Zoology, University of Michigan, Ann Arbor, Michigan.*

FISHES OF THE RED SEA AND SOUTHERN ARABIA; VOLUME I. BRANCHIOSTOMIDA TO POLYNEMIDA. By Henry W. Fowler. Weizman Science Press of Israel, Jerusalem, 1956: 240 pp., 117 figs., $6.00.—This is the first of a planned three volume work on the fishes of the Red Sea, Suez Canal to Port Said, Gulf of Aden, Gulf of Oman and the Persian Gulf. The manner of presentation (text, taxonomic arrangement, keys, and outline figures) follows closely Fowler's two volume work, "The Marine Fishes of West Africa". As in the latter, the first volume of this Red Sea work covers the same families of marine fishes but with a different ordinal system. It includes one lancelet, all the elasmobranchs (76 species), and 263 species of teleosts included under the seldom used ordinal names of Clupeida, Myctophida, Halosaurida, Notacanthida, Muraenida, Silurida, Cyprinodontida, Belonida, Coryphaenoidida, Gadida, Pleuronectida, Pegasida, Syngnathida, Berycida, and Polynemida.

This work is mainly a survey of the literature. Following a page and a half introduction the text includes a listing of the species with the original reference for each, regional synonomies, condensed descriptions or short diagnoses and the locality of the specimens examined. Total length of specimens are given sometimes in inches, or mm., or both. In many cases the distribution of the species is indicated. There are also short descriptions of higher categories (Classes, Orders, Suborders, and Families) and keys down to species. The latter are helpful in many cases but in some the characteristics listed are completely overlapping [e.g., D. 15 to 18 (usually 17, rarely 15) as compared to D. 16 to 17 (usually 17) used in separating *Hippocampus kuda* from *H. Hippocampus*.] The keys are not

of the dichotomous type but list up to six choices. The outline figures done by the author are what he terms "unfinished details in pen and ink" and are mostly copied from the literature.

Ichthyologists interested in the areas covered will find this a handy volume and those working on identifications will be grateful for the compilation of the literature which is widely scattered and mostly in foreign journals—a job that probably only Mr. Fowler with his extraordinary knowledge of world literature on fishes could have compiled in reasonable time. It has been over 65 years since a comprehensive book has been prepared on Red Sea fishes. (The early books on the Red Sea by Forskal, Ruppell and Klunzinger, including lavish color plates, are now collectors' items.) Blegvad's 247 page volume on the "Fishes of the Iranian Gulf" (1944) Part III of the Danish Scientific Investigations in Iran has been the only recent publication to assemble data on the general fish fauna of even a sub area covered by Fowler.

Mr. Fowler attempts no broader application of the material he presents and omits reference to Dr. Gohar's important discussion of the Red Sea ichthyofauna (Hydrobiologi, Series B, vol. 2, pt. 2/3, 1954) and to recent papers presenting studies on the exchange of fish species through the Suez Canal. Although the jacket claims this book contains "information not previously published" I could find no significant evidence of it.

The great amount of endemism in the Red Sea makes highly desirable an examination of actual specimens from that area for any critical study. Unfortunately our museums have very little material for such purposes. Even Fowler, in his studies of vast collections of Indo Pacific (the Red Sea and Souther Arabian waters are zoogeographical subdivisions of the Indo Pacific region) and African fishes in connection with the preparation of monumental volumes covering these areas, has examined first hand less than half of the 340 species covered in this latest book. In only 8 cases did he examine specimens of species from the Red Sea. Fowler's forthcoming volumes will undoubtedly contain more of his first hand information as his recent collaborations with Drs. Steionitz and Ben Tuvia in Israel enable him to examine new collections from the Gulf of Aqaba.

There are a few omissions such as Duncker's paper on Red Sea syngnathids (Publ. Mar. Biol. Sta. Ghardaqa No. 3—1940) describing *Phanerotokeus gohari* a common pipefish at Ghardaqa. There is also lack of reference to any of the interesting morphological and embryological studies of Red Sea fishes by Egyptian scientists who worked at the Marine Biological Station at Ghardaqa which even in a taxonomic review could bear mentioning as there have been so few studies made of Red Sea fishes.

LIVING REPTILES OF THE WORLD. By K. P. Schmidt and R. Inger. Hanover House, Garden City, New York, 1957: 287 pp., 266 illustrations, 145 in color, $10.—Though I know that both authors thought of this book as a "pot boiler", it turns out to be not a bad memorial to the senior author. It is certainly far from an ordinary "pot boiler". There has rarely been a prettier book and yet this is no mere picture book. It is packed with more herpetological fact and is a completer semipopular survey of the world of reptiles since Hans Gadow's "Amphibians and Reptiles" in 1901.

The illustrations are often suberb, and only a very few show just another turtle or just another snake. There has been some effort to show the activity of animals as well as their general appearance. The classic picture of the tree-climbing *Elaphe* is reproduced. Feeding, egg-laying and hatching are shown for several forms. The colored plates are, of course, a main attraction of the book and are not only unusually numerous but in general more faithful to natural color than is usual.

The text is systematic in arrangement and carefully organized. Every existing family has a discussion appropriate in length to its importance or interest and, in every case, there is both a general section on adaptations, structures and habits and then a geographic section in which all or most genera receive mention. Forms with peculiar adaptations (such as *Draco* and *Chlamydosaurus* among the agamids) receive attention both in the general and in the geographic sections. This involves some repetition but is only unfortunate when occasional errors are made. It is, for instance, unhappy to have it *twice* stated incorrectly that *Xiphocercus* has a prehensile tail. (It is still very much a question which iguanids have prehensile tails.) Such errors (or outdated information) are fortunately rare, but another should receive mention since it occurred also in Pope's "Reptile World": *Sphaerodactylus elegans* is not one of the two smallest lizards; it is only the young of *S. cinereus*.

The classification is in the main conservative. The leptotyphlopids remain snakes, and there is no lumping of families in any group. Indeed, the only somewhat unusual taxonomic action in the book is the treatment of the oriental water snakes as a full family, Acrochordidae.

It will be no surprise that the writing is as

pleasant as the pictures are attractive. There is many a vivid anectdote interspersed among the more technical information.

In simple summary, the book is highly recommended.

ADAPTIVE COLORATION IN ANIMALS. By Hugh B. Cott. Methuen, London, 1957: 508 pp., 84 figs., 48 plates and a colored frontispiece, 75 shillings—Reissue of a classic. The discussion of animal coloration on Neo-Darwinian principles utilizes many examples from among amphibians, reptiles and fishes.

KNAURS TIERREICH IN FARBEN: REPTILIEN. By K. P. Schmidt and R. Inger, Droem. Verlagsanst. Knaur Nache, Munich: 311 pp., 280 illustrations, 145 in color, ca. $8.50.—This is "Living Reptiles" translated into German by Dr. Heinz Wermuth with some additional black and white figures and some added text. A bargain if you read German fluently or want only the pictures.

SNAKES AND SNAKE HUNTING. By Carl Kauffeld. Hanover House, Garden City, New York, 1957: 266 pp., photos., $3.95.—Book reviews should be severe in proportion to the pretensions of the book reviewed. A review of this one in a museum journal was, oddly, cool and several prospective reviewers have complained about the too ecstatic descriptions of snake catching by the author.

But this seems a captiously over-professional attitude. This book has no pretensions; it is not intended for the bored professional. Its purpose is to entertain and casually to instruct the amateur who is or might be interested in snakes,

EDITORIAL NOTES AND NEWS

Copeia Costs

COPEIA for 1958 is being printed by linotype (instead of monotype) on coated paper. This paper is of equal quality to the paper used in previous years and has a great advantage in that halftones may be used at much lower cost. This use of linotype and coated stock reduces the cost of publication about $200.00 per issue. The Editor-in-Chief invites comments from members.

Copeia Mailing Dates, 1957

Copies of COPEIA for 1957, mailed first-class to the Editor-in-Chief, were postmarked at Baltimore, Maryland, as follows: No. 1, April 15; No. 2, July 25; No. 3, Sept. 1; No. 4, Dec. 20.

Research Grants and Publication

The cost of publication is now generally recognized as an integral part of the cost of research. Most government agencies and foundations will permit the payment of costs of publication from research funds.

Several leading biological journals have more than sixty percent of their printing costs paid by the research grants and contracts of their authors. In contrast, COPEIA has less than two percent of publication costs paid from this source.

Ichthyologists and herpetologists are urged to request funds for publication in their research proposals. The following excerpt is from the publication of the National Science Foundation, "Basic Research—A National Resource."

"In recent years the Government agencies which support basic research by contract or grant have recognized the principle that *publication is the indispensable outcome of research.* To the extent that they are able, either under their statutes or regulations, they allow acceptance of page charges by the institutions in which they support research. The Interdepartmental Committee on Scientific Research and Development has distributed a report among Federal agencies designed to dispel uncertainties and confusion concerning the legality of such payments. It recommends a liberal policy in regarding them as part of research costs.

Certain safeguards are called for. Charges should be levied by the journals in accordance with uniform practice applying to all authors. Page charges on a voluntary basis must be administered without intent or implication that papers from institutions which honor page charges should be shown preference; contributions must continue to be accepted solely because of their scientific merit".

Reprints

The ASIH makes no profit on reprint sales. The sale of reprints is managed by Waverly Press. Many members of the ASIH assume that the purchase of reprints pays a part of the cost of publication. This is incorrect.

Why not more News Notes?

Members frequently request the Editor-in-Chief to publish more news notes. Such notes can not be provided by the Editor. Members are urged to submit information on their activities for this section of COPEIA.

Biological Abstracts

FRED R. CAGLE is sectional editor for Amphibia and Reptilia of Biological Abstracts. Actions have been taken to broaden the scope of these sections through the inclusion of abstracts from some of the three hundred serials publishing herpetological information. The suggestions of herpetologists are invited.

Salaries and Biologists

The American Institute of Biological Sciences has protested vigorously the exclusion of biologists from recent salary increases for scientists employed by government. Many of the biologists involved are in the fields of fishery biology and wildlife management. But these two groups of biologists have not supported the AIBS.

The apparent reason for not increasing the salaries of biologists is the failure of government agencies to justify such increases. Why was this not done? Are biologists second-class scientists? Do we have an ample supply of biologists? Or, are biologists poorly organized in comparison to the physical scientists?

Quarterly Review of Biology

The Quarterly Review of Biology is now published by the AIBS. The editors have invited the ASIH to suggest topics for review articles and the names of persons competent and willing to prepare book reviews. Members' recommendations should be directed to the Secretary.

University of Miami

The establishment of a doctoral program in the marine sciences has been announced by the University of Miami. Ph. D. degrees will also be offered in the three fields of Marine Biology, Fisheries, and Oceanography, under the Department of Marine Sciences. The academic department is staffed by senior members of The Marine Laboratory, engaged in a wide variety of research projects.

Courses in ecology, physiology, biochemistry and taxonomy of marine animals, and courses in phycology, plankton and other specialized aspects of marine biology are offered by a staff including Dr. H. B. Moore, Dr. Charles Lane, Dr. F. G. Walton Smith, Dr. Gilbert Voss, Dr. Harding Owre. Fishery ichthyology training is offered by Dr. C. P. Idyll, Dr. C. Richard Robins, Dr. John Randall and Mr. Edwin S. Iversen. The oceanography courses, including geological, chemical, physical and meteorological aspects, are taught by Dr. Fritz Kocsy, Dr. Cesare Emiliani, Dr. Eugene Corcoran, Mr. Homer Hiser and Mr. Sigmund Miller.

Enquiries may be addressed to Dr. C. P. Idyll, Chairman of the Department of Marine Sciences, University of Miami, 1 Rickenbacker Causeway, Miami 49, Florida.

Western Division

The Western Division, ASIH, will hold its 1958 meeting in conjunction with the Pacific Division, AAAS, at Utah State University, Logan, June 16-20. Sessions are scheduled for Wednesday–Friday, June 18–20.

Philadelphia Herpetological Society

The PHS, in its sixth year, has 212 members and subscribers. The official publication, Bulletin of the Philadelphia Herpetological Society, is published bimonthly. The bulletin contains: news and collecting notes from all parts of the country; book reviews; special supplements on distribution and ecology; a classified section; and articles of general herpetological interest. Membership and subscription cost is $2.00 per year; subscription only is $1.50 per year. Inquiries should be addressed to: The Philadelphia Herpetological Society, 7102 Rising Sun Avenue, Philadelphia 11, Penna.

Ho

Pre
Vic

Tre

Sec

Pu

Ed

Ed

Pr
Vi

Sec

Pr

Vi

Sec

L.

tu
cil
bu

Hu

be

Ga

pa

COPEIA IS THE JOURNAL OF THE AMERICAN SOCIETY OF ICHTHYOLOGISTS AND HERPETOLOGISTS

Affiliations

The American Society of Ichthyologists and Herpetologists is a member of the American Institute of Biological Sciences and of the Division of Biology and Agriculture, National Research Council, and is an affiliate of the American Association for the Advancement of Science. An annual contribution is made to the publication of the Zoological Record.

Back numbers of Copeia, as available, may be procured from Prof. N. B. Green, Biology Dept., Marshall College, Huntington, West Virginia. Prices will be furnished on application.
Subscription, $9.00 per annum, $2.50 a copy.
Dues to Society: foreign and student members $6.00 annually; regular members $8.00 annually; sustaining members $25.00 annually.
Life membership: $150.00 single payment.
Patrons: $1000.00 single payment.
All memberships include subscription to Copeia.
Dues and subscriptions are payable to the Society, through the Secretary.
Members should notify the Secretary immediately of any changes in address.
Manuscripts, news items, and all correspondence regarding the Journal should be addressed to the Editor.
Manuscripts should be submitted on good paper, as original typewritten copy, double-spaced, carefully corrected. Galley proof will be furnished authors.
Original contributions from members of the Society, not to be published elsewhere, are alone acceptable.
Reprints are furnished at approximate cost.
Figures, author's corrections, expensive tabular matter and unusually long articles may be charged in whole or in part to the author at the discretion of the Editor.

ΙΧΘΥΣ
ΒΑΤΡΑΧΟΣ
ΕΡΠΕΤΟΝ